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WITH PLATE I.

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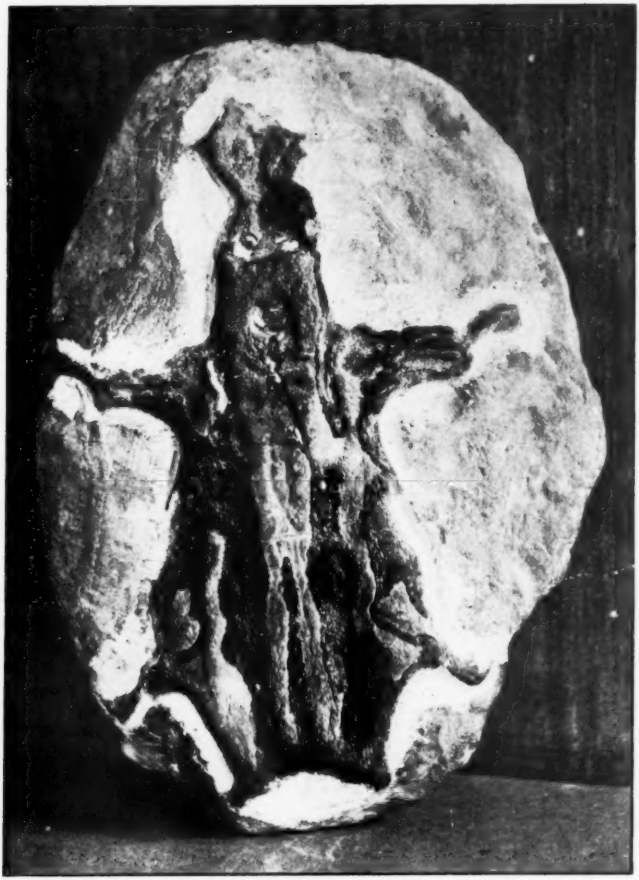


TAMIOBATIS VETUSTUS.

Dorsal aspect of cranium, two-thirds natural size. From a photograph taken by Dr. T. A. Jaggar, Jr.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. X.—*Tamiobatis vetustus; a new Form of Fossil Skate;* by C. R. EASTMAN. With Plate I.

THROUGH the kindness of Mr. F. A. Lucas, of the United States National Museum, the writer has enjoyed the opportunity of studying a remarkable fossil belonging to the collection under the charge of this gentleman. The specimen (Nat. Mus. Cat. No. 1717) was identified by Mr. Lucas as "the skull of a fossil skate," and is shown by the records to have been found in the eastern part of Powell County, Kentucky. Unfortunately, the exact horizon from which it was obtained is not affirmed by the original memoranda accompanying the specimen, but its history seems to leave no doubt that it was derived from rocks occurring *in situ* in that part of Kentucky.

Characters of the matrix.—The fossil is embedded in a weathered block of greenish-gray limestone having a slightly talcose feel, and soft enough to be easily scraped with a knife. The matrix was examined both macroscopically and in thin sections* for traces of other organic remains; but beyond a

* A thin section and fragments of the surrounding rock were submitted recently to Dr. Charles Palache, who was kind enough to furnish the following note upon their mineralogical characters:

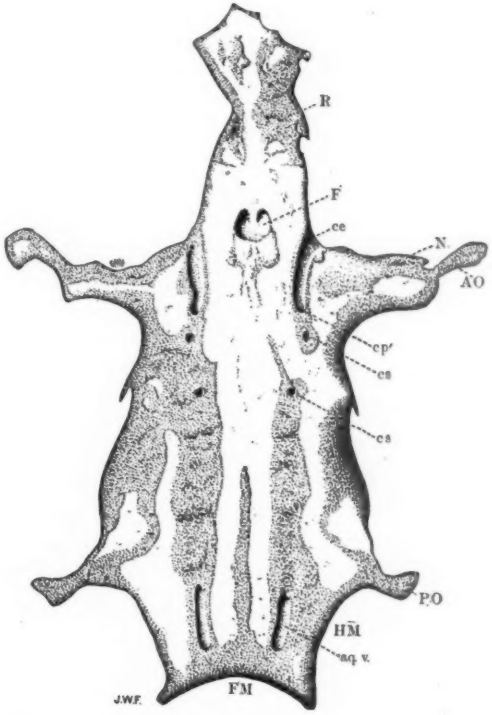
"The rock is a very soft greenish-gray limestone, somewhat greasy to the touch. On the under surface it shows a concentric structure, the nodules being small and developed about many centers; but this structure is not sufficiently pronounced to enable one to decide from it either for or against a concretionary origin for the specimen. The rock dissolved readily in cold dilute acid, leaving a residue which amounted to less than one-fourth of the whole, and proved on examination under the microscope to be composed of fragments of feldspar and scales of a kaolin-like mineral. It is doubtless to these scales of kaolin that the rock owes its greasy feel, for the proved absence of magnesia shows that talc is not present, as was at first suspected. Silica is also absent."

few minute fragments of Bryozoa and Foraminifera, themselves incapable of precise determination, no accompanying structures were observed. Hence, the only intrinsic evidence as to geological age is that afforded by petrographical characters, and by a study of the fossil itself. But neither class of intrinsic evidence can be altogether relied upon in the present case, owing chiefly to insufficiency of material for comparison; and beyond conceding that the specimen is undoubtedly Palæozoic, we must content ourselves with a statement of opinion that it belongs to such or another horizon. Professor N. S. Shaler, formerly state geologist of Kentucky, is inclined to believe it is from the Waverly group. Mr. Charles Schuchert, who is also familiar with the stratigraphy of the region, ventures the opinion that it was derived from the Corniferous or its equivalent. No other formations besides the Devonian and Carboniferous are represented in the eastern part of Powell County; and this is far beyond the limit of transported material. We may therefore feel a reasonable amount of assurance in assigning our fossil provisionally to the Middle or Upper Devonian.

Description of the remains.—A very fair representation of the specimen is shown in Plate I, and also in the accompanying text-figure, both being of two-thirds the natural size. Obviously it is the cranium of a fossil Elasmobranch, seen from the dorsal aspect; and the characters which at once suggest affinities with the rays are the elongated rostrum, prominent nasal capsules, and antorbital processes for attachment with the pectoral fins. The general form of the skull is fiddle-shaped; there are evenly-rounded cavities for the eyes; the position of the hyomandibular and foramen magnum is indicated; and the median fontanelle as well as openings for the passage of nerves are perfectly distinct. A fontanelle proper does not occur in sharks, the cranial cavity being open in front; and although the tegmen cranii now under discussion differs considerably from existing rays, the above enumeration of features shows that it is decidedly more skate-like than shark-like.

The extreme length of the cranium is 16^{cm}, and its width between the tips of the antorbital spurs is 11^{cm}. It is quite possible that the anterior portion of the rostrum is broken off, although an expansion occurs at the forward part which appears to have been symmetrical and normal. If the rostrum were actually as short, and terminated in the manner shown, a resemblance is to be noted to the conditions existing in *Torpedo*, *Narcine*, and others of the electric rays. But the cutwater is wider, heavier, and less tapering than in recent forms; and the median fontanelle does not appear to have extended forward as

an elongated cavity, nor is it flanked by the compact rods of rostral cartilage, usually so distinct in the skull of both fossil and living skates. In fact, the tegmen cranii would seem to be more completely closed than in either sharks or skates, such as exist at the present day, or are known from the Mesozoic and later rocks. It is scarcely necessary to remark that the substance composing the fossil is calcified cartilage, and the bare spaces are where it has been weathered or worn away. The crust has in places a thickness of about 3^{mm}; superficially it is



Tamiobatis vetustus gen. et sp. nov. $\times \frac{2}{3}$. *AO*, Antorbital process; *F*, Fontanelle; *FM*, Foramen magnum; *HM*, Position of hyomandibular; *N*, Nasal capsules; *PO*, Postorbital process; *R*, Rostrum.

quite smooth and compact, but where partially abraded it is seen to be composed of small aggregations which represent the centers of calcification. No dental or integumentary structures are to be observed.

The olfactory capsules (*N*) are slightly abraded along the anterior margin, and it is impossible to detect a suture between them and the antorbital spurs (*AO*). On the other hand, there is a small cleft, which might easily be mistaken for a suture, passing across each of the postorbital processes in a longitudinal direction. But these fissures have every appearance of being fortuitous, and moreover show tool-marks along the edges where they were probed into before reaching the hands of the present writer. Although of unusual size for postorbital processes, we have no choice but to regard them as such; for, if suturally united with the cranium, they can be homologized with nothing else than the metapterygoid, an element with which they agree neither in shape, size, nor point of attachment. Again, if it were possible to detect sutures here, like indications ought also to exist where the antorbital processes are attached. Granted that they are postorbital processes ("sphenotic" Parker), their size and distal expansion may be accounted for, perhaps, by supposing that membranes were attached to them for the support of the anterior gill arches or other structures. They slant outward and downward so as to occupy the same level, distally, as the tips of the antorbital processes.

The hyomandibular was presumably attached along the sinus marked *HM*. Bounded on either side by prominent occipital condyles was the foramen magnum (*FM*), and here the chondrification was very dense. Just back of the capsules for the eyes on either side is to be seen a small reëntrant angle in the cranial wall. The cartilage is quite thick in this vicinity, and appears to have been eroded by natural causes in the first instance, and further pricked away with the needle so as to produce the effect indicated. It is rather curious that accidents of fossilization and weathering should have affected both sides of the object symmetrically in so many particulars.

The nerve openings are readily identifiable, and have been lettered to correspond with the classic illustrations of Gegenbaur* and Parker.† The superior opening of the ethmoid canal is at *ce*, that of the preorbital canal at *cp'*; *cs* marks the foramina supraorbitalia, present here in two pairs only; and *aq.v.* is the aqueductus vestibuli. All of these openings are very distinct, and their walls densely chondrified.

Probable relationships and systematic position.—If remains of the dentition or dermal ossifications had been preserved in connection with the present specimen, or if skeletons of other

* Untersuchungen zur vergleichenden Anatomie der Wirbelthiere, Heft III. Das Kopfskelet der Selachier, 1872.

† On the Structure and Development of the Skull in Sharks and Skates (Trans. Zool. Soc. London, vol. x, pt. iv), 1878.

Palæozoic Tectospondyli were known, we would not have so slender a basis for comparison; but as it is, we are singularly limited. True, evidence is not wanting to show that cartilaginous fishes with a much-depressed body, probably like that of existing rays, were plentiful in the Palæozoic. The teeth known as Psammodonts, for instance, belonged undoubtedly to ray-like Elasmobranchs; but no trace of their skeletons has yet been discovered. We should not expect them, however, to differ very widely from Mesozoic or even recent rays; their bodies were more generalized, of course, partaking of the nature of both shark and skate; but the idea that the distinction between a shark-skull and a skate-skull was not brought about until the skates began to specialize markedly along particular lines (i. e., since the Jurassic), cannot be entertained. In fact, it does not strike us as surprising that a Palæozoic skull, such as has just been described, should present the resemblance it does to the crania of existing skates. The specimen at hand merely proves what has long since been postulated,—that there were Palæozoic forerunners which were very like Mesozoic rays; and it is to be observed that a number of Mesozoic genera survive at the present day. So far material has been lacking to demonstrate the conservatism as well as remote antiquity of the ray tribe; but as the palæontological record becomes more fully revealed, we shall probably find that this group diverged very early from the parent stem, and did not become highly modified until comparatively late in time.

Of existing families, the Rhinobatids and Myliobatids are generally believed to represent the most nearly ancestral form of ray, and it is natural to look to them first of all for furnishing points of resemblance to the present specimen. But as we have here nothing more than the skull to base comparisons upon, and this is not sufficiently characteristic, it is manifestly impossible to single out any one genus or even family and declare that the fragment approaches it more closely than other living types. We can only affirm that the fossil skull indicates a very generalized condition; it presents some features that are shark-like, and differs notably from the skulls of existing rays. Doubtless the fin-structures and body-parts were also generalized; the indications are that the skeleton of the pectoral fins was not continued forward to the snout; and the dentition was probably weak. In all these respects there is an agreement with *Rhinobatus*, obviously because it, too, possesses a generalized organization; but there are differences in detail which prevent it from being included under the same family. With still less propriety can it be assigned to any other recognized family; but as the group to which it belongs is imper-

fectly definable, there seems to be no other course than to leave it under the head of *incertæ sedis*, or to place it in an appendix to the *Rhinobatidæ*, or possibly the *Myliobatidæ*.

A knowledge of the remainder of the organization of so ancient a fish could not fail to prove of exceptional interest. Where one stratum or concretion is capable of preserving a fragile structure like this, the chances are that more abundant and more perfect material will eventually be forthcoming; and it is not without the hope of stimulating further research that the present contribution is put forward.

As it becomes necessary to designate the above described individual by a special title, notwithstanding its imperfect condition it is suggested that the name *Tamiobatis* be employed for the genus, in allusion to its fancied resemblance to the body of *Tamias*. Specifically it may be known as *Tamiobatis vetustus*.

Museum of Comparative Zoology, Cambridge, Mass.

ART. XI. — *The Florencia Formation;* by OSCAR H. HERSHEY.

Introduction.—Great progress has been made during the past decade in the study of American Quaternary deposits, and the literature on the subject is already voluminous; but the field is so extensive that many portions of it remain practically untouched. These obscure corners contain much of the evidence which in the future must be relied on to dispose of many of the unsolved problems now before the geologic public. It is by a gradual accumulation of a vast body of facts that we will finally be enabled to read the Quaternary history of America with great accuracy. Hence, every addition to our knowledge of the superficial geology of the continent, however trivial it may appear at the time, possesses some value as increasing our familiarity with the products of the era. On this account I feel it justifiable in placing on record this description and definition of the formation whose designation forms the title of this paper.

Description.—The Florencia formation is distinctly differentiated into two principal members. The lower is a moderately coarse subangular gravel. It is largely local in origin, in northwestern Illinois, Galena limestone constituting often as

much as 90 per cent of the mass. This was derived by stream erosion from the Pleistocene rock gorges. There is also a certain percentage of drift pebbles which were secured in the erosion of the till and gravel ridges of the district. The rock fragments are sometimes angular, but usually are as well rounded as the Galena limestone will admit by stream action. They are much stained by the hydrated sesquioxide of iron. Some of these stains are a dull earthy black in color, but the greater part are a reddish brown. Locally the iron oxide is present in such amount as to cement the gravel into a soft conglomerate rock. There are rarely any shells or woody matter in this lower or gravel division, as it formed an unfavorable environment for the animal life of the streams, and was deposited at so low a level as not to catch any of the driftwood.

The structure of the Florencia gravel is not very distinct, but in places it is seen to be irregularly stratified. The surface is everywhere uneven or rapidly undulating. As it is a river deposit, we may presume that this irregularity of the surface is due to its having constituted the stream-bed and not the flood-plain deposit of the Florencia subepoch. The depressions between the ridge-like elevations of the gravel represent the deeper portions of the streams, while the higher portions of the deposit are the sites of the ancient gravel bars. It is a curious circumstance that the subsequent erosion of this gravel has been so slight that the ancient gravel bars now form rapids in some of the present streams, as in the lower course of Yellow creek. Indeed, the beds of all the larger streams of Stephenson county, Illinois, are nearly everywhere composed of this gravel, overlain in the deeper portions by a little brown silt and mud. That the gravel which forms bars in their beds is not the Modern river gravel except in a few instances, is known from its outcrop in the banks at one or both ends of the bars. The Florencia gravel is distinguished from the Modern stream gravel by its much greater rounding, a larger percentage of drift pebbles, and its peculiar ferruginous staining. Its stratigraphic relations, also, serve to distinguish it.

The ancient stream gravel now under discussion outcrops in the banks of Crane, Yellow, and tributary creeks and just under the low-water level of the Pecatonica river. It is never exposed to a greater height than two feet, and its total thickness is unknown. Near Bolton a well was reported to have penetrated "blue gravel and driftwood" to a thickness of ten feet. In the Pecatonica river valley it seems to be largely replaced by ferruginous sand, and to extend twenty or more feet below the present river level. It constitutes the main body of the Florencia formation; but to the geologic student the upper division is of vastly greater interest.

Resting upon the irregular surface of the bed of gravel there is a series of dark blue-green silt, light brownish gray sand, and dark brown carbonaceous clay or muck. The passage from the gravel to the finer sediment is usually quite abrupt, although they are sometimes slightly interstratified. The dark brown muck fills the depressions in the surface of the gravel and varies in thickness from six inches to several feet. It is horizontally stratified, and where the remains of herbaceous vegetation form thin layers, it may be said to be laminated. It contains some small shells, but is not the most fossiliferous member of the formation. What it lacks in the remains of the fauna it partly supplies in the inclusion of many semi-decayed branches and trunks of trees. These are quite numerous in the Crane creek outcrops, and appear to be of two main kinds, one of which is light brown in color and the other black. They are somewhat flattened by pressure, but the branches and trunks represented had an original diameter of one inch or less up to one foot.

The blue-green silt and the light brownish gray sand are in lenticularly-shaped "pockets" interstratified with each other and with the upper portion of the muck. The sand is of well-rounded grains, mostly of transparent quartz, with all the drift rock species represented. It contains a moderately abundant supply of shells, all of small species. But the blue-green silt is the great shell-bearing member of this formation. The species are of a great variety, as the lists later to be presented will indicate, but the shells are all of small size. They are in such abundance that they often make up 10 per cent of the mass. Several hundreds may be separated from a single cubic inch of the silt. This fact constitutes this the most highly fossiliferous formation developed in northwestern Illinois.

Each of the three lithologic types presented by the upper division of the Florencia formation is characteristically distinct from any other of the district, and they together constitute a series of strata which can be readily identified in every outcrop. The blue-green silt is peculiar to this formation and seems to be coextensive with its distribution, as it has been detected in every outcrop which I have closely examined. The invariable stratification of the entire series, the close association of the most abundant "pockets" of shells with certain lithologic features, and the fact that all the vegetable matter, including the semi-decayed logs or tree trunks, lies in a horizontal position, demonstrate that this division of the formation is not a flood-plain deposit properly so-called, but represents the sediment and driftwood laid down over the gravel in the stream bed, after the land area had begun to subside, thereby establishing a permanently flooded condition of the streams.

Distribution.—Because of the very incomplete condition of the study of the Quaternary geology of northwestern Illinois, the Florencia formation is known to the writer in the Pecatonica basin only. Here it is found, wherever the proper horizon is exposed, along nearly all the streams of Stephenson county, but has been studied mainly in the valleys of Crane and Yellow creeks and the Pecatonica river. Its outcrops, although fairly numerous, never rise more than a few feet above the stream level, and are usually somewhat obscured by a talus from the bank above. For this reason, the formation has probably failed of investigation in other districts of this portion of the Mississippi basin; but as it represents conditions which were not limited to northwestern Illinois, its existence in all the deeper valleys of this and neighboring states can hardly be doubted. In Stephenson county, the most significant feature of its distribution is the fact that, unlike the drift and loess deposits, it is confined strictly to a certain level. Its upper surface forms a plane which scarcely varies from eighteen inches to two feet above the present low-water level of the streams. It is, therefore, a fluvial formation and can extend from the present streams only so far as the sides of the valleys which were excavated in the drift and rock after the Kansan epoch. In the Yellow creek and the Pecatonica river valleys near Freeport, its width may vary from an eighth to a mile; and in western Winnebago county, its borders are probably two miles apart. It has been estimated that if that portion of the formation which is developed in Stephenson county, were spread as a uniform sheet over the surface of the entire county, it would have a thickness of about six inches.

Stratigraphic relations.—Because of the very interesting nature of the fossil contents, it is of the greatest importance that the age of the Florencia formation be definitely fixed, and this necessitates a careful investigation of its stratigraphic relations. It rests upon the Kansan drift sheet everywhere except where post-Kansan erosion has completely removed the till and other glacial deposits. It is, therefore, separated from the latter by an erosion interval of the length of which the interglacial rock gorges of this region* are the gauge. The Florencia formation passes through these rock gorges, completely burying their flat bottoms. Its age is, therefore, not earlier than the practical completion of these gorges. Now the presence of the Iowan *loess* series at various places within them has demonstrated that in age they correspond mainly to the Aftonian epoch. This would seem to indicate that the

* The Pleistocene Rock Gorges of Northwestern Illinois, American Geologist vol. xii, No. 5, November, 1893.

Florencia formation dates from about the time of the passage from the mild conditions of the Aftonian to the somewhat severer climatic conditions of the Iowan epoch.

The Florencia formation is overlain with perfect conformity by the basal member of the Iowan *loess* series. The latter varies much in constitution from place to place, but in the Crane and Yellow Creek valleys is a highly ferruginous bright red clay, usually only a few inches in thickness. This ocherous layer derived its large constituent of iron oxide from the red Aftonian soil of the surrounding hills. The upper portion of the Florencia formation, as already intimated, presents evidence that the subsidence of the region had already advanced so far as to produce a general flooding of the streams. A little later, either through a sudden increase in the movement of land depression, or the obstruction of the mouth of the Pecatonica valley by the advancing Iowan ice-sheet, the flooded Florencia streams were converted into long narrow lakes which gradually deepened and eroded the red soil on the valley slopes, redepositing it at lower levels as a red and brown sand and the "ferruginous layer" of our Crane and Yellow Creek sections. Almost immediately the extensive fauna and flora of the Florencia streams and valleys were totally destroyed, so that the Iowan *loess* deposits are practically unfossiliferous.

Several miles northeast of the village of Pecatonica in Winnebago county, there is a section which displays finely the entire series of the Iowan *loess* resting with perfect conformity upon the Florencia formation. The latter is exposed from the river level to a height of three feet, and is a bed of laminated and variegated clay which, by the erosion of the river, is made to simulate indurated shales. There are a great many black semi-decayed logs projecting from the bank into the river. They reach a thickness of one foot and lie in the position of driftwood. Over this Florencia clay comes, first, a stratified bed of brown sand, then a less distinctly laminated stratum of fine silt or typical *loess*, followed by the ordinary and easily recognized "main body" of the *loess* series, or Upland *loess*, as I have previously denominated it. Each member of the series is distinct and they have a combined thickness at this locality of 30 feet.

As I shall show presently, the climatic conditions at the time of the deposition of the Florencia formation in northwestern Illinois, as indicated by the faunal remains, were apparently nearly identical with those usually considered typical of the Aftonian epoch, while its physical relations to the rock gorges and to the overlying *loess* series, together with a presumed presence of the ice, supported by some evidence, on the east

side of the Rock river valley, would seem to connect it with the Iowan epoch. Therefore, we cannot with full confidence refer its age to either epoch, but may perhaps more properly consider it as occupying a transitory stage between the Aftonian and Iowan epochs.*

Fauna.—Collections of shells have been made from two principal localities. The first is in the bank of Yellow creek about 100 feet east of the Chicago, Milwaukee & St. Paul Railroad bridge, and is referred to as the Indian Garden locality, the name having been derived from a popular designation of the peninsularly-shaped body of land enclosed by the creek in the great bend which it makes in the vicinity of the mouth of Crane creek. Great care was taken in securing the shells that they actually came from the Florencia formation and not from Modern silt and muck which might have been deposited on the former by the present stream. An excavation was made into the bank and the fossils secured from under the *loess* which appears higher in the section. No mistake can have been made, as the strata of blue-green silt, light brownish gray sand and dark muck which everywhere in this region form the upper division of the formation, were here present with all their characteristic features, and the shells were taken from undisturbed or originally stratified portions of them. This care was taken because it was early recognized that a fauna of a very similar facies occurs in the Modern alluvial deposits, and the two might easily be confounded.

The second place from which collections were made is the Crane Creek locality. Here the same care was taken as in making the other collection. I do not think there is a possibility of a mistake having been made, as the blue-green silt is typically developed and the loess appears in unmistakable form above it.

These collections of Florencia shells were submitted to Dr. W. H. Dall of the U. S. Geological Survey, who has identified them as in the following lists:

*Since this discussion of the stratigraphic relations of the formation was written, I have become aware of the establishment of a new classification of the Illinois and Iowa drift. This applies the term "Aftonian" to an interglacial stage preceding the formation of the Kansan drift-sheet. It, also, establishes a new sheet of drift intermediate in position between the Kansan and Iowan sheets; this is designated the Illinoian drift-sheet. As it is now doubtful which sheet is exposed in Stephenson County, Illinois, and what term should be applied to the long deglaciation interval following, my use of the words "Kansan" and "Aftonian" should be considered as tentative, and relative to the term "Iowan." This will not affect the "age" of the formation, which undoubtedly belongs immediately before that of the Iowan *loess* series. See editorial in American Geologist, vol. xix, No. 4, April, 1897.

Indian Garden locality.	Crane Creek locality.
Fresh-water species.	
Pleurocera subulare Lea.	*Pleurocera subulare* Lea.
Planorbis parvus Say.	*Campeloma decisa* Say.
" *bicarinatus* Say.	*Pisidium* spec. ?
Valvata tricarinata Say.	" *variabile* Prime.
Limnæa humilis Say.	" *compressum* Prime.
Vivipara spec. ? juv.	" *virginicum* Gmel.
Ancylus tardus Say ?	" *fallax* Sterki.
" *rivularis* Say.	" *punctatum* Sterki.
" *parallelus* Hald.	*Valvata tricarinata* Say.
Pisidium spec. ?	*Planorbis bicarinatus* Say.
" *walkeri* Sterki.	" *parvus* Say.
" *cruciatum* Sterki.	*Limnæa desidiosa* Say.
" *fallax* Sterki.	*Sphærium solidulum* Say ?
" *punctatum* Sterki.	" *striatinum* Lam.
" *compressum* Prime.	" *staminium* Lam.
" *variabile* Prime.	" *semile* Say.
Campeloma decisa Say, juv.	*Segmentina armigera* Say.
" (embryonic).	*Physa heterostropha* Say.
Sphærium staminium Con. ?	*Somatogyrus depressus* Tryon.
" *striatinum* Lam.	*Amnicola cincinnatiensis* Auth.
Physa heterostropha Say.	*Bythinella tenuipes* Couper.
Bythinella tenuipes Coup.	
Amnicola povata Say ? juv.	Terrestrial species.
" *cincinnatiensis* Auth.	*Vallonia costata* Mull.
Cypris (crustacean).	*Zonitoides arboreus* Say.
Ostracod crustacean.	*Hyalinia radiatula* Ald.
	" *minuscula* Binn.
Terrestrial species.	" *indentata* Say.
Hyalinia radiatula Alder.	*Pyramidula alternata* Say.
" *minuscula* Binn.	" *striatella* Auth.
Helicodiscus lineatus Say.	*Helicodiscus lineatus* Say.
Pyramidula striatella Auth.	*Succinea avara* Say.
Pupa contracta Say.	*Pupa ventricosa* var. *elatior* Sterki.
" *corticaria* Say.	*Pupa contracta* Say.
" *holzingeri* Sterki.	" *holzingeri* Sterki.
Succinea avara Say.	" *armifera* Say.
Carychium exile Ad. ?	*Polygyra* spec. ?
" *exiguum* Say.	" *hirsuta* Say.
Vallonia perspectiva Sterki.	*Vertigo indentata* Wolf.
Strobilops virgo Pils.	

To the above lists of shells from the Florencia formation I will add *Pisidium abditum* Hald? which was included in a small collection from this horizon made near Bolton several years ago.

An analysis of the species contained in these lists shows that there are undoubtedly present at least fifty distinct varie-

ties, of which thirty are of fresh-water forms and twenty air-breathing or terrestrial species. In comparing them with the lists of shells from the *loess* at Davenport, Muscatine and Iowa City, published by McGee in his memoir on "The Pleistocene History of Northeastern Iowa,"* some interesting differences are noticed. In the Iowa *loess* fauna the gasteropods are mainly pulmoniferous, only a few freshwater species having been discovered. In the Florencia fauna near Freeport, the larger number of species are of freshwater forms, but the *Uniodæ*, which appear in the loess, are absent from this formation. The genus *Helix*, which occurs in the *loess* fauna of Iowa and is plentiful in the Modern alluvial deposits of Illinois, has not been identified in the collections made from the Florencia formation. Furthermore, many of the terrestrial species of the Iowan *loess* are not present in the Florencia fauna as at present known. There is thus seen to be such a great difference between the fossil contents of the two formations as to point to a great contrast in conditions. The preponderance of freshwater species in the Florencia fauna indicates the fluvial nature of the formation just as certainly as do its physical features.

The significance of the fossils of the Florencia formation lies chiefly in the evidence which they furnish of the nature of the climate of that time. Undoubtedly it was neither Arctic nor very cold temperate. I hereby submit the proposition that these fossils demonstrate that the climate was similar to the present. So far as I am aware, there is nothing about the shells which indicates the proximity of a glacier or the existence of conditions favorable to the accumulation of land ice. On the contrary, the prevailing reddish color of the soil on the neighboring uplands as proved by its condition to-day (buried under the *loess*), and the ferruginous layer at the base of the *loess* series, points to a comparative mildness of the climate of that time. This is corroborated by the large amount of driftwood and the vast quantities of small shells enclosed in the Florencia formation, which indicate that organic life was more abundant in the valleys and streams then than it is at present. This abundance of animal and vegetable life is in strong contrast with preceding and succeeding epochs. The Silveria formation contains a few shells of several terrestrial species and a few very small pieces of lignitiferous wood; the Lake Pecatonica formation is totally unfossiliferous; and the drift nowhere presents any evidence of organic remains. Throughout the Kansan epoch the climate in this region was undoubtedly severe. During the formation of the Iowan *loess*

* 11th Annual Report of U. S. Geol. Survey, pages 460 and 471 of Part I.

series, the conditions were again unfavorable for organisms in northwestern Illinois, as the *loess* of this district is practically unfossiliferous. A few shells have been observed in the *loess* on the bluff at Freeport, and lately a small collection was made from the same formation on the top of the Oakdale esker, about four miles south of Freeport and 100 feet above Crane creek, which is several hundred yards distant. They are exclusively of *Succinea avara* Say. These are the only shells which I have observed in the *loess* of this district except that sometimes over the Florencia formation the shells of the latter have been disturbed and redeposited in the lower portion of the *loess*.

From a study of the Florencia and Iowan Loess formations I have concluded that, in northwestern Illinois, the peculiarly mild climatic conditions of the Aftonian epoch continued almost unchanged into the earlier portion of the Iowan epoch; so that the Aftonian flora and fauna remained until long after the beginning of the great movement of depression which characterized the Iowan epoch in this region, and even until the Iowan glaciers had closed around the district on the east and west and were approaching the culmination of their advance. The destruction of the Florencia fauna was produced less by the presence of the glaciers near by than by the rather rapid conversion of the valleys into lake basins through the general subsidence of the region.

Nomenclature.—The name which I have applied to the formation discussed in this paper is a slight modification of a term once used to designate the basal or fluvial member, as it was then considered, of the Iowan *loess* series of this region. It was referred to as the Florence gravel, the name having been derived from the township of Florence, in Stephenson county. The great diversity of the Quaternary deposits in the Pecatonica basin has driven me, for the want of a sufficient number of important geographical names, to the necessity of applying township designations to some of the formations discriminated, and this is a case in point. But the term as originally used is of such common occurrence in Europe and America, that I have considered it justifiable in the interests of convenience, definiteness, and euphony to modify the termination of the word. Therefore, I desire that henceforth the deposit be referred to as the *Florencia formation*.

Freeport, Ill., March 18, 1897.

Art. XII.—*Native Iron in the Coal Measures of Missouri;* by E. T. Allen.

The occurrence of native iron of terrestrial origin has been until recently a mooted question with mineralogists. In the fifth edition of Dana's Mineralogy bearing the date 1868, we read: "The occurrence of masses of native iron apart from meteoric origin is not placed beyond doubt." We now have on record, however, a considerable number of occurrences of terrestrial iron which such authorities as Dana and Tschermak admit to be genuine. Terrestrial iron is claimed to have been found (1)* in eruptive rocks, (2)† in river sands, sometimes associated with gold or platinum, (3) in obvious connection with‡ carbonaceous matter, (4)§ in various other situations.

A careful study of the literature of this subject does not convince one that a number of the specimens described may not have been meteoric, or in some cases, perhaps, artificial. Others, the origin of which is more probable or even established, were obtained only in dust, grains, or very small pieces, so that a study of the physical properties must have been difficult. In many cases we have no published analyses. The number of irons, which are undoubtedly terrestrial and concerning which we have full and satisfactory data, is still so small that new discoveries may possess some interest.

During the past year we have received at this laboratory a number of such specimens of remarkable purity. These were obtained from different localities in Missouri, but proved on inquiry to have a similar origin and paragenesis and almost identical composition and properties.

I. *Natural Iron from Cameron, Clinton Co., Mo.*

This iron, which was received in December, 1895, was obtained in largest quantity and has been most fully examined. It was discovered in drilling out an old well on the land of Mrs. Mary E. Reed of Cameron. Twenty-five years before, the well had been sunk thirty-seven feet till a layer of sand-

* Meunier, C. R., lxxxix, 215, 1879. Smith, Ann. Ch. Phys., V, xvi, 402, 1879. Andrews, this Journal, II, xv, 443, 1853. Hawes, ibid., III, xiii, 33, 1877. Cooke, Ann. Rep. State Geol. N. J., 1874, p. 56. Bornemann, Pogg. Ann., lxxxviii, 145, 1853.

† Hussak, this Journal, III, vol. xliii, 177, 1892. Page, ib., xxv, 160, 1883. Daubrée and Meunier, C. R., cxiii, 172, 1891. Genth, Proc. Phil. Soc., Philad., xi, 443, 1870.

‡ Shepard, this Journal, xl, 366, 1841. Bahr, ib., II, xiv, 275. Bornemann, l. c.

§ Hayes, this Journal, II, xxi, 153, 1856; xxviii, 137, 1857. Genth, ib., xxviii, 246, 1859. Hoffmann, Proc. R. Soc. Canada, Sec. III, p. 39, 1890. Ann. Rep. State Geol. N. J., 1883, p. 162. Clemson, Trans. G. Soc. Penn., i, 358, 1834. Journ. Phys, xli, 3.

stone was reached. In 1895 it dried up for the first time. Accordingly the owner decided to deepen it. After drilling through fourteen feet of solid sandstone, the iron was struck at a depth of fifty-one feet. An eight-inch drill and a five hundred pound beater were employed, but so refractory was the vein (or pocket) that the workmen gave up the attempt to penetrate it. On learning from us the nature of the substance, small portions of which were brought to the surface, the work was continued, but it required over half a day to go through it. The workmen judged the thickness of the vein or pocket to be five or six inches. Solid sandstone was found again on the other side of the iron, into which the drilling was continued for twenty-three feet, when the water rose to the same height. We learned on inquiry that no coal or shale was found in the boring although the place is in a coal region and coal has been discovered within five miles.

Examination of sandstone.—The sandstone matrix of this natural iron was of a very light brown color and of moderately fine grain. It possessed a calcareous cement amounting to over thirty per cent of its weight, a little iron in the form of ferric oxide and small quantities of alumina. A microscopic examination of a small portion which had been treated with hydrochloric acid showed that the residue consisted almost entirely of quartz grains. An analysis yielded the following results:

Insoluble in hydrochloric acid		64·14
[Of this 63·52 per cent = SiO_2]		
Soluble in hydrochloric acid	$CaCO_3$	30·90
	$MgCO_3$	·89
	Al_2O_3	2·65
	Fe_2O_3	1·27
		99·85

The sample of sandstone was considerably crumbled when we received it. From the crumbled portion we extracted a large number of bits of metallic iron with the magnet.

The metal.—The majority of these pieces, both those contained in the crumbled sandstone and those received separately, were flattened and irregular in shape, often hackly around the edges and weighed about half a gram. When they reached the laboratory all were slightly tarnished or coated with a thin film of rust, but when first taken from the ground no rust was visible, we were informed, though none of the pieces were bright except where fresh fractures had been made by the drill. The resistance which the iron offered to the drill showed that there was a solid mass imbedded in the stone, and this mass was evidently beaten to pieces. The iron was so malleable that it could be beaten out cold on an anvil to very thin plates, though not without cracking somewhat on the edges. Its hardness was just about that of fluorspar, the minerals

scratching one another with difficulty. When filed the metal exhibited a color almost silver white and a high luster which remained permanent in a dessicator. While most of the pieces weighed about ·5 gr., there were a number which weighed 2 grms. or more, one weighed 8·4 grms. and the largest 45·4 grms. The last was only a little darkened by tarnish when we received it. On the edge a layered structure was very noticeable. In the other pieces this was not so apparent, but they often separated along cleavage planes when hammered and by the aid of a pair of pliers, one layer after another, sometimes exceedingly thin, could be peeled off more or less perfectly. The surface between these layers was sometimes blackened, but often entirely fresh and metallic. Probably on account of this structure and perhaps also on account of unequal hammering by the drill, the specific gravity of different pieces varied considerably. That of the largest was only 7·43, while that of the smaller pieces varied (after the outer layer was removed) from 7·63 to 7·73. The layered structure also made it difficult to produce a continuous polished surface, the boundaries of the layers showing in it as fine irregular lines at whatever angle the plane was cut. The action of dilute nitric acid was tried on such a surface, but it appeared to attack it evenly, developing no semblance to Widmanstätten figures. In the chemical examination of the iron we employed only the metallic core prepared by filing away the outer layers. This dissolved in hydrochloric acid with the evolution of hydrogen which possessed comparatively little odor, and left a very slight residue of crystalline silica and a few minute fragments of carbonaceous matter. A careful analysis of a solution prepared from several grams of the iron, failed to reveal any traces of copper, nickel, cobalt or other foreign metals. With the exception of oxide of iron, silica, phosphorus and carbon in small quantities were the only impurities detected. The analyses made of different pieces gave nearly identical results.

IRON—

1. Metal taken = ·2910 gr. $KMnO_4$ required = 42·53^{cc}. 1^{cc} = ·006785 gr. iron. Fe = 99·16 per cent.

An examination of the iron taken, by means of a lens, showed small dots of rust in a few places that seemed to penetrate deeply. Other determinations made on smaller pieces where the rust appeared to have affected the iron still more gave lower results.

2. Metal taken = ·2147. $KMnO_4$ required = 31·31^{cc}. Fe = 98·93.
3. Metal taken = ·4611. $KMnO_4$ required = 66·88^{cc}. Fe = 98·40.

SILICA—

1. Metal taken = 3·1603 gr. SiO_2 obtained = ·0117 gr. = ·37 per cent.
2. Metal taken = 5·2953 gr. SiO_2 obtained = ·0196 gr. = ·37 per cent.

The silica obtained was all in the form of minute crystalline grains, and since the iron was found imbedded in sandstone it appeared not unlikely that the grains were originally present as such in the metal. A microscopic examination of the interior of several pieces threw no light on this point.

CARBON—

This was determined by dissolving the iron in potassium cupric chloride and collecting the carbon dioxide formed by burning the residue.

1. Metal taken	1·4036 gr.
CO_2 obtained	·0038 gr.
C	·07 per cent
2. Metal taken	2·4820
CO_2 obtained	·0055
C	·06 per cent

PHOSPHORUS.

Metal taken	3·1603
$Mg_2P_2O_7$	·0237 gr.
P	·207 per cent

Complete Analysis.

Fe	99·16
SiO_2	·37
C	·065
P	·207
	99·802

II. *Natural Iron from Weaubleau, Hickory Co., Mo.*

This iron was received from the firm of Butler & Whitaker of Weaubleau, who discovered it while digging for coal about five miles from that place. They drilled through twenty-seven feet of interstratified sandstone and clay, when they reached a thin seam (two or three inches in thickness) of poor lignite. Eight feet deeper, at a total depth of thirty-five feet, they struck a stratum of gray clay in which were a few pieces of metallic iron. Considerable coal seemed to exist in the vicinity, as they found it eighteen inches thick at the same depth, not far from this spot.

The clay contained 79·32 per cent silica and 1·67 per cent iron. When the iron was first taken from the earth, it was dark with tarnish though not apparently rusted. Only a few pieces were obtained. We received but two, which after filing away the outer portions weighed respectively 3 grms. and 3·9 grms. Both physically and chemically the iron strongly resembled the Cameron specimens. The layered structure was not however so marked and the percentage of metallic iron was

a little higher, probably on this account. The specific gravity of the larger piece was 7·58. Of two small fragments of the other, weighing about half a gram each, we found the specific gravities 7·83 and 7·88.

Analysis.

IRON—

1. Metal taken = ·3919 gr. 59·57^{cc} $KMnO_4$ required. 1^{cc} = ·006530 gr. Fe. Fe = 99·27 per cent.
2. Metal taken = ·3830 gr. 58·37^{cc} $KMnO_4$ required. Fe = 99·52 per cent.
3. Metal taken = ·1596 gr. Dissolved in hydrochloric acid, precip. by NH_4OH and determined as Fe_2O_3.

$Fe_2O_3 + FePO_4$	·22697 gr.
Cal. for $FePO_4$	·00047
Fe_2O_3	·22650 Fe = 99·34 per cent

SILICA—

Metal taken = 3·2052 gr. SiO_2 = ·0100 gr. SiO_2 = ·31 per cent.

PHOSPHORUS—

Metal taken = 3·2052 gr. $Mg_2P_2O_7$ = ·0148 gr. P = ·128 per cent.

Analysis.

Fe	99·39
SiO_2	·31
P	·13
C	undetermined.

III. *Natural Iron from Holden, Johnson Co., Mo.*

This iron was discovered by Mr. G. W. Hills of Holden while drilling a well. The upper strata passed through consisted chiefly of fire-clay. At a depth of 21 ft. coal was struck. This continued for 18 in., and then followed fire-clay again until at a depth of 37 ft. the drill struck something hard which caused it to rebound. After some time, no headway being made, the drillings were examined. A few small pieces of metal about the size of lima beans were drawn up with the clay. The discoverer informed us that he drilled out altogether about as much of the substance as one could hold in the hand. As he was disappointed in his original object the well was eventually filled up.

We received specimens of the drillings and one piece of the metal which weighed about 3 grms. The clay in which the iron occurred was compact and gray in color. It contained 65·25 per cent of silica and 3·63 per cent of iron. When first brought to the surface, the iron resembled tarnished silver, but showed no signs of rust. Its hardness was about the same as that of the two specimens previously described, sp. gr. = 7·49.

After solution in aqua regia a considerable residue of silica, which was partly gelatinous, and some carbonaceous matter remained.

SILICA—

2·9929 gr. iron taken. Silica = ·0495 gr. = 1·65 per cent.

IRON—

The filtrate from silica was diluted to 500^{cc} and aliquot parts were titrated with permanganate solution.

a. 25^{cc} sol. required 23·08^{cc} $KMnO_4$.
b. 20 " " 18·47 "
1^{cc} KMnO = ·006292 gr. Fe.
Iron = (*a*) 97·09 (*b*) 97·10

The specimen analyzed was not examined until several months after it was taken from the ground and, although all the outer portions were carefully filed away before the analysis, it was probable that the rust had penetrated deeply and that small portions were unremoved. The original percentage of metal was probably higher.

PHOSPHORUS—

405^{cc} of the filtrate mentioned above was examined for phosphorus.

$Mg_2P_2O_7$ obtained = ·0155 gr. P = ·176 per cent.

Analysis.

Iron	97·10
Silica	1·65
Phosphorus	·176
Carbon	undetermined.

Conclusion.—All the specimens here described were found at such a depth from the surface and under such conditions that there can be no doubt of their terrestrial origin. That they were portions of the drill, is of course untenable, not only because the drills remained intact but because of the remarkable softness of the specimens, their peculiar structure (in the case of the Cameron specimens) and the remarkable resistance which two of them offered to the drill. The close connection of two of them with coal and the location of the third in the same geological formation (the Coal Measures) and in the comparatively near vicinity of coal, is significant of their origin, though the minute quantity of carbon in the metal is notable. Whatever the process of reduction, the location of the irons in all three cases was very favorable to preservation.

As regards composition, not only is the purity of these specimens remarkable, but it is interesting to note the absence of nickel, an element always found in meteoric irons, but rarely in those of terrestrial origin.

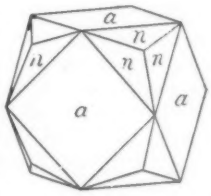
School of Mines of the University of Missouri,
Rolla, Missouri.

ART. XIII.—*On Bixbyite, a new Mineral, and Notes on the Associated Topaz;* by S. L. PENFIELD and H. W. FOOTE.

Bixbyite.—The mineral to be described in the present article was sent to us for identification by Mr. Maynard Bixby of Salt Lake City, Utah. Concerning its occurrence we are informed that the mineral is found very sparingly in one or two small areas on the edge of the desert about thirty-five miles southwest of Simpson, Utah. The crystals are implanted upon topaz and decomposed garnet and rhyolite and have evidently been formed by fumarole action.

The mineral crystallizes in the isometric system, usually in cubes, some of which measure over 5^{mm} on an edge. These are occasionally modified by the trapezohedron, 211, and on one small specimen the cubes and trapezohedrons are developed with almost ideal symmetry as shown in fig. 1. When measured on the goniometer the crystals gave fairly good reflections of the signal and $211 \wedge 112$ was found to be 33° 40′; calculated 33° 33½′. The mineral breaks with an irregular fracture, and on one or two specimens traces of octahedral cleavage were observed. The color is brilliant-black with metallic luster, and the streak is black. The hardness is 6 to 6·5. The specific gravity of the material used for the quantitative analysis was taken on a chemical balance and found to be 4·945. The mineral fuses before the blowpipe at about 4 and becomes magnetic. When very finely powdered, it dissolves with some difficulty in hydrochloric acid with evolution of chlorine.

1.



Method of Analysis.—The material for analysis was separated in a nearly pure condition by the thallium-silver nitrate mixture. The mineral was treated with strong hydrochloric acid in a flask connected with a condenser, and the chlorine liberated was distilled over into a solution of potassium iodide. Free iodine was then determined volumetrically with standard thiosulphate and iodine solutions, from which the amount of available oxygen was calculated. After filtering off a small amount of insoluble material, iron, aluminium and titanium were separated from manganese and magnesium by the basic acetate method. The three oxides were weighed together, iron was then determined by titration with permanganate solution and titanium was twice precipitated by boiling the nearly neutral dilute sulphate solution for two hours in the presence of

sulphur dioxide. It was weighed as TiO_2. From the filtrate from the basic acetate precipitation, manganese was precipitated with excess of bromine water. The precipitate, after filtering, was dissolved in a solution of sulphur dioxide, precipitated as phosphate and weighed. Magnesium was precipitated from the first manganese filtrate as phosphate.

Following are the results of the analyses:

	I.	II.	Average.	Ratio.
SiO_2	1·24	1·19	1·21	
Al_2O_3	2·57	2·48	2·53	
Fe_2O_3	47·81	48·15	47·98	·300
TiO_2	1·62	1·78	1·70	·022
MnO	42·08	42·02	42·05	·592
MgO	0·12	0·09	0·10	·002
Avail. O	4·37	4·39	4·38	·274
	99·81	100·10	99·95	

The silica and alumina are regarded as impurities, as only a trace of them went into solution when the mineral was treated with hydrochloric acid. In preparing the mineral for analysis, a variation in specific gravity was observed, owing to the fact that some of the dark particles were buoyed up by impurities, but in order to obtain sufficient material for analysis, it was necessary to include some of the lighter portion. It is probable from the results of the analysis that some topaz was present, for the ratio of silica to alumina is about 1 : 1 and topaz is intimately associated with the bixbyite.

Leaving silica and alumina out of account, two formulas are possible. Considering the titanium as Ti_2O_3, the oxygen derived from the TiO_2, 0·16 per cent, plus the available oxygen, 4·38, total 4·54 per cent, is about sufficient to convert the MnO into Mn_2O_3, the amount required for 42·05 per cent, MnO being 4·74. The composition therefore can be expressed as R_2O_3, where R = Fe, Mn and a little Ti. The proportion of Fe to Mn is 1 : 0·99 or almost 1 : 1, so that disregarding Ti_2O_3, the composition is $FeMnO_3$. If the mineral is an isomorphous mixture of Fe_2O_3, Mn_2O_3 and Ti_2O_3 we should expect it to be rhombohedral and to belong to the hematite, corundum and menaccanite group, and also it is not probable that the Fe and Mn would be present in the proportion 1 : 1.

As the mineral is isometric, it seems more reasonable to regard it as a compound having essentially the composition $FeO.MnO_2$ and related to the isometric mineral perofskite, $CaO.TiO_2$. On this basis, the results of the analysis may be put in the following shape:

		Ratio.	
FeO	43·17	·600	
MgO	0·10	·002	= ·602
MnO	42·05	·592	
TiO_2	1·71	·021	= ·613
Avail. O and O from Fe_2O_3	9·18	·574	
SiO_2	1·21		
Al_2O_3	2·53		
	99·95		

The ratio of Fe+Mg : Ti+Mn is ·602 : ·613 or nearly 1 : 1, while the oxygen is almost sufficient to convert the MnO into MnO_2 as indicated by the ratio MnO : O = ·592 : ·574. As oxygen was determined perhaps as accurately as any other constituent, it seems possible that a small amount of manganese may be present as protoxide, replacing FeO. If enough manganese be taken as protoxide to make the ratio of RO to RO_2 exactly 1 : 1, the results become:

		Ratio.	
FeO	43·17	·600	
MgO	0·10	·002	·608
MnO	0·40	·006	
TiO_2	1·71	·021	
MnO	41·65	·587	·608
O	9·18		
SiO_2	1·21		
Al_2O_3	2·53		
	99·95		

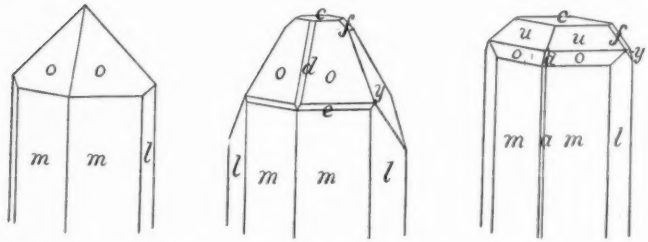
The oxygen necessary to convert 41·65 per cent of MnO to MnO_2 is 9·38, which is only slightly in excess of that actually found in the analysis. It seems therefore probable that the mineral is essentially $FeMnO_3 = FeO . MnO_2$, in which small quantities of MgO and MnO are isomorphous with FeO and a little TiO_2 with MnO_2. The mineral is therefore to be regarded as a ferrous salt of manganous acid H_2MnO_3, corresponding to braunite $MnMnO_3$, which is supposed to be the manganese salt of the same acid.

We take pleasure in naming this mineral after Mr. Bixby, who has generously supplied us with material for investigation, and has gone to a great deal of trouble and pains to secure the specimens.

Topaz.—On the topaz with which bixbyite is associated the following forms were observed:

a, 100 *m*, 110 *d*, 201 *y*, 041 *u*, 111
c, 001 *l*, 120 *f*, 021 *o*, 221

2. 3. 4.



The prevailing types of the crystals are shown in figs. 2, 3, and 4. Some of the crystals are more than 4^{cm} long and are transparent and colorless; a few have a delicate wine color, and many are either opaque white or partially so. The opaque crystals, as shown by microscopic examination, are not pseudomorphs but consist of fresh unaltered topaz containing minute quartz crystals, which evidently have been included during crystallization.

Associated with the topaz crystals are rough trapezohedrons which apparently were once garnet, but which have suffered alteration. The garnet is wholly gone and the crystals consist of bixbyite with either quartz, topaz or both. The garnet was probably the manganese variety, spessartite, which has been observed by Cross* at Nathrop, Colo., associated with topaz in rhyolite, an occurrence similar to that in Utah.

Art. XIV.—*Note concerning the Composition of Ilmenite;* by S. L. Penfield and H. W. Foote.

The existence of a molecule $R^{II}O \cdot R^{IV}O_2$ in bixbyite and perofskite brings to mind the views concerning the composition of ilmenite. One of these is, that the mineral is $RO \cdot TiO_2$ (R=Fe and Mg), as advanced by Mosander† and adopted by Rammelsberg‡ and Hamberg.§ The other, that it is R_2O_3, or an isomorphous mixture of Fe_2O_3 and Ti_2O_3, as advanced by Rose‖ and adopted by Groth.¶

* This Journal, xxxi, p. 432, 1886.
† Pogg. Ann., xix, p. 219.
‡ Pogg. Ann., civ, p. 497.
§ Geol. Fören., i, Stockholm Förhandl., xii, p. 604.
‖ Pogg. Ann., lxii p. 119.
¶ Tabellarische Übersicht der Mineralien, 3 Aufl., Braunschw., 1889, p. 40.

There are both crystallographic and chemical grounds for accepting Mosander's formula. Hematite and artificial Ti_2O_3 both crystallize in the rhombohedral division of the hexagonal system, and the lengths of their vertical axes are respectively 1·359 and 1·316. Ilmenite, however, differs in its symmetry from the foregoing, for it crystallizes in the rhombohedral-tetartohedral division of the hexagonal system, and the length of its vertical axis, 1·385, is not between those of hematite and titanium sesquioxide, which would be expected if ilmenite were an isomorphous mixture of Fe_2O_3 and Ti_2O_3. Moreover, if the two sesquioxides are isomorphous it would be expected that at times the Ti_2O_3 would be in excess of the Fe_2O_3, which has never been observed, although in some cases the ratio of Fe : Ti is practically 1 : 1.

The presence of the protoxide magnesia in almost all of the ilmenites that have been examined cannot be accounted for if the mineral is assumed to be an isomorphous mixture of the sesquioxides Fe_2O_3 and Ti_2O_3. The quantity of magnesia is usually small, less than five per cent, but Cohen* has described an ilmenite from Du Toit's Pan, South Africa, occurring in rounded grains which contain 12·10 per cent MgO, and Rammelsberg† a crystallized one from Layton's Farm, Warwick, N. Y., containing 13·71 per cent MgO. Groth,‡ in commenting upon Rammelsberg's analysis, points out that the material might have been impure. Having on hand in the Brush collection some excellent crystallized specimens from this locality, we thought it best to make a new analysis. The material was derived from a single crystal. This was rough so that accurate measurements could not be made, but the habit was that of ilmenite, and by means of the contact goniometer the forms *c*, 0001, *r*, $10\bar{1}1$ and *s*, $02\bar{2}1$ were identified. The analysis (by Foote) is given below, together with that made by Rammelsberg:

	I.	II.	Average.	Ratio.		Rammelsberg.	Ratio.	
SiO_2	0·44	0·31	0·37	·006	·722	----		
TiO_2	57·30	57·28	57·29	·716		57·71	·721	
FeO	24·08	24·23	24·15	·335	·749	26·82	·372	·727
MgO	16·01	15·93	15·97	·399		13·71	·342	
MnO	1·09	1·12	1·10	·015		0·90	·013	
Fe_2O_3	1·99	1·75	1·87	·012		----		
	100·91	100·62	100·75			99·14		
Specific gravity			4·345			4·303		

* Jahrb. Min., 1877, p. 695. † Loc. cit. ‡ Loc. cit.

In the two analyses, the ratio of $RO_2 : RO$ is very close to 1 : 1, thus indicating the existence of the molecule $RO . TiO_2$, where R = Fe and Mg.

It is thus *definitely proved* that in this crystallized variety of ilmenite there is a molecule $MgO . TiO_2$ or $MgTiO_3$, and it seems most reasonable to suppose that the iron also is present as $FeO . TiO_2$, isomorphous with $MgO . TiO_2$, and not as an isomorphous mixture of Fe_2O_3 and Ti_2O_3. It cannot, however, be told by chemical means that all of the titanium exists as a tetravalent element, for on dissolving the mineral for analysis, Ti_2O_3 if present would oxidize to TiO_2 at the expense of Fe_2O_3 and the analysis would show an equivalent of FeO. ($Fe_2O_3 + Ti_2O_3 = 2TiO_2 + 2FeO$).

In the published analyses of ilmenite, where the ratio of $TiO_2 : RO$ is very constantly 1 : 1, there is almost without exception an excess of Fe_2O_3, amounting in some cases to a large per cent, as may be seen by examining the list of analyses in Dana's System of Mineralogy, p. 218, and, as Hamberg has pointed out, it is reasonable to suppose that the hematite molecule Fe_2O_3 or $FeFeO_3$ is capable of mixing with the ilmenite molecules $FeTiO_3$ and $MgTiO_3$, just as $CaCO_3$ and $NaNO_3$ are practically isomorphous.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School, New Haven, Conn., April, 1897.

ART. XV.—*The Separation of Aluminum and Beryllium by the action of Hydrochloric Acid;* by FRANKE S. HAVENS.

[Contributions from the Kent Chemical Laboratory of Yale University– LXIV.]

IN a former paper* a method was described for the determination of aluminum in the presence of iron, based upon the fact that the hydrous aluminum chloride $AlCl_3 . 6H_2O$ is practically insoluble in a mixture of strong hydrochloric acid and anhydrous ether saturated with hydrochloric acid gas, while the ferric chloride is entirely soluble in that medium.

The work to be described in this paper is an extension of this process to cover the separation of aluminum from beryllium, with the subsequent determination of the beryllium by weighing as the oxide after conversion to the nitrate and ignition.

The aluminum chloride solution was prepared by dissolving the so-called pure aluminum chloride of commerce in as little water as possible, precipitating and washing free from iron with strong hydrochloric acid, dissolving the chloride thus obtained in water, precipitating the hydroxide by ammonia, washing the precipitate free from all alkalies, and redissolving it in hot hydrochloric acid. From this solution, after cooling, gaseous hydrochloric acid precipitated the pure hydrous chloride. This prepared chloride was dissolved in water and the solution standardized by precipitating with ammonia the hydroxide from weighed portions and weighing as the oxide. The solution of beryllium used was made by dissolving in water beryllium chloride found to be free from iron by the sulfocyanate test, and giving no precipitate when tested by the gaseous hydrochloric acid process to be described later on. This was standardized by precipitating with ammonia the hydroxide from weighed portions and weighing the ignited oxide in the usual manner.

In the experiments of Table I, weighed portions of the aluminum solution were mixed with portions of the beryllium chloride solution representing from ·01 gram to ·10 gram of the oxide, an equal volume of a mixture of strong hydrochloric acid and ether (taken in equal parts) was added to the solution of the mixed chlorides, and the whole was completely saturated with gaseous hydrochloric acid while kept at a temperature of about 15° C. by immersing the receptacle in running water. Ether was added, equal in volume to the aqueous

* Gooch and Havens, this Journal, vol. ii, December, 1896.

aluminum and beryllium solutions originally taken, and the current of gas again turned on until saturation was complete. By this treatment there is present at the end of the saturation a volume of ether equal to that of the aqueous hydrochloric acid introduced and generated. The finely crystalline precipitate of aluminum chloride was caught on asbestos in a filter crucible, washed with a previously prepared mixture of hydrochloric acid and ether in equal parts saturated at 15° C. with hydrochloric acid gas, and dried for half an hour at a temperature of 150° C. It was next covered with a layer of pure mercuric oxide, which had been tested and found to leave no residue on volatilizing, and the crucible was gently heated over a low flame under a ventilating hood and finally ignited over the blast.

TABLE I.

	Al_2O_3 taken in solution as the chloride.	Al_2O_3 found.	Final volume, cm^3	Error.
(1)	0·1046	0·1044	12	0·0002—
(2)	0·1046	0·1038	12	0·0008—
(3)	0·1067	0·1066	12	0·0001—
(4)	0·1071	0·1063	12	0·0008—
(5)	0·1059	0·1054	30	0·0005—

From these results it is obvious that the aluminum chloride may be determined in the presence of beryllium chloride with reasonable accuracy.

The beryllium may be recovered in the filtrate from the aluminum chloride by precipitation with ammonia after nearly complete evaporation of the acid. It was found, however, upon trial that the conversion of the chloride to the oxide without precipitation and filtration may be easily accomplished by treatment with nitric acid and ignition. The results of Table II indicate this clearly. In these experiments weighed portions of the beryllium solution were evaporated just to dryness on a radiator, care being taken not to heat to the volatilizing point of the beryllium chloride, a few drops of strong nitric acid were added, the liquid was evaporated, and the residue heated—at first gently, to break up the nitrate safely and finally on the blast. It was found that this conversion of the beryllium to the nitrate can be carried on in platinum without attacking that metal appreciably, providing care be taken to remove thoroughly all excess of hydrochloric acid before the nitric acid is added to the dry residue.

TABLE II.

	BeO taken in solution as the chloride.	BeO found.	Error.
(1)	0·0483	0·0481	0·0002 −
(2)	0·0483	0·0483	0·0000
(3)	0·1076	0·1085	0·0009 +

In Table III, (1)–(9), are given the results of experiments in which both the aluminum and the beryllium were determined—the former by precipitation as the hydrous chloride and weighing as the oxide after igniting with mercuric oxide: the latter by the conversion of the chloride, through the nitrate, into the oxide. In experiment (10) (made to get a comparison of the methods) the beryllium was recovered by precipitating the hydroxide with ammonia from the partially evaporated solution of the chloride after removing the aluminum.

In experiments (1) to (5), inclusive, the aluminum was determined exactly as previously described; in (6) and (7) the solutions (being originally larger) were concentrated by evaporation previous to the addition of the ether and hydrochloric acid mixture. In experiments (8), (9) and (10), the treatment was varied advantageously by saturating the aqueous solution directly with hydrochloric acid gas before adding an equal volume of ether, and completing the saturation.

TABLE III.

	Al_2O_3 taken in solution as the chloride.	Al_2O_3.	Error.	Final volume.	BeO taken in solution as the chloride.	BeO found.	Error.
(1)	0·1059	0·1058	0·0001 −	12^{cms}	0·0198	0·0204	0·0006 +
(2)	0·1053	0·1044	0·0009 −	12	0·0194	0·0196	0·0002 +
(3)	0·1065	0·1059	0·0006 −	12	0·0197	0·0205	0·0008 +
(4)	0·1068	0·1060	0·0008 −	12	0·0199	0·0207	0·0008 +
(5)	0·1049	0·1047	0·0002 −	12	0·0198	0·0208	0·0010 +
(6)	0·1060	0·1057	0·0003 −	12	0·0977	0·0969	0·0008 −
(7)	0·1064	0·1063	0·0001 −	12	0·1085	0·1084	0·0001 −
(8)	0·1046	0·1038	0·0008 −	30	0·1083	0·1087	0·0004 +
(9)	0·1051	0·1048	0·0003 −	30	0·1071	0·1078	0·0007 +
(10)	0·1076	0·1075	0·0001 −	30	0·1086	0·1094	0·0008 +

These results are plainly very good.

The manipulation of the process is not difficult. The gaseous hydrochloric acid is most conveniently produced by the well known method of treating with strong sulphuric acid in

regulated current a mixture of strong aqueous hydrochloric acid and common salt. A platinum dish hung in an inverted bell-jar, provided with inlet and outlet tubes through which the current of water for cooling is passed, makes the best container for the solution to be saturated with the gas. It is advantageous to arrange the filtration upon asbestos so that the filtrate and washings may be caught directly in the crucible (placed under the bell-jar of the filter pump) in which the subsequent evaporation is to be effected. The heating of the strong acid solution must be gradual and conducted with care to prevent mechanical loss by a too violent evolution of the gaseous acid.

It only remains to thank Professor Gooch for kind suggestions and advice.

Art. XVI.—*Igneous Rocks of the Leucite Hills and Pilot Butte, Wyoming;* by Whitman Cross.

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Contents.

Introduction.
Rocks of the Leucite Hills.
The Rock of Pilot Butte.
Chemical Composition of the Rocks Described.
Classification and Nomenclature.
Inclusions in the Leucite Hills Rocks.

Introduction.

In 1871, in the course of the geological explorations along the 40th parallel, S. F. Emmons found the first leucite-bearing rock to be discovered on the American continent in a small group of hills in southwestern Wyoming, which received on this account the name of the Leucite Hills. The description of the locality given by Mr. Emmons in the reports of the Fortieth Parallel Survey* is very brief, being based upon reconnaissance observations made before the unusual interest attaching to the rocks of the region had been ascertained. A petrographical description of the leucite rock in question is contained in the report by Prof. F. Zirkel† upon the microscopical characters of the rocks of the 40th Parallel collection.

As far as I am aware no further description of the leucite rocks of Wyoming appeared until J. F. Kemp's communication upon them was presented to the Geological Society of America, in December, 1896.‡ The material described by Kemp was much better illustrative of the variation existing in the Leucite Hills lavas than was that examined by Zirkel. He also had specimens of the singular rock from Pilot Butte, a point situated some miles west of the Leucite Hills. Zirkel does not describe the Pilot Butte rock, but a short account of it is given by Emmons.§ The specimens from Pilot Butte in the 40th Parallel collection, preserved in the National Museum, are like the material obtained by Kemp and myself, and Emmons's megascopical description clearly applies to them; but his statements of their microscopical constitution indicate that a no longer explicable confusion of thin sections led him to describe the rock of Pilot Butte as a plagioclase-bearing trachyte, whereas it is entirely free from feldspar.

Major John W. Powell also visited Pilot Butte in the course

* Vol. ii, Descriptive Geology, 1877, pp. 236–238.
† Vol. vii, Microscopical Petrography, 1876. pp. 259–261.
‡ Published in Bull. Geol. Soc. Amer., vol. v, 1897, pp. 169–182.
§ Reports of the Fortieth Parallel Survey, vol. ii, 1877.

of his geological explorations, and collected specimens identical in character with those described by Kemp and in the course of the present paper. For the opportunity of examining Major Powell's specimens I am indebted to Mr. J. S. Diller, in whose hands they had been placed for study.

The observations communicated in the following pages are based upon a trip to the Leucite Hills made a number of years ago. That their publication has been so long deferred is partly due to the pressure of other work, and largely to a desire—thus far not realized—to revisit the region before publication in order to greatly extend my observations. In view of the unusual interest attaching to the rock types to be described, I feel that an explanation of the inadequate character of my field observations in the Leucite Hills is not out of place. The visit to this locality was made late in the fall of 1884, with an assistant, W. B. Smith, for the express purpose of collecting a large number of specimens of the leucite rock for the "Educational Series" then being assembled by the Geological Survey. No mineralogical variation in the rocks of the region was indicated by the descriptions of Emmons and Zirkel, and, as none could be detected by the naked eye, such variation was not suspected at the time of my visit. The weather became very stormy soon after our arrival, and snow covered the hills a part of the time. For these reasons my observations do not make plain the field relations of the types collected, whose differences were chiefly evident only after microscopical study. Pilot Butte was visited during one of the terrific sand storms for which this part of Wyoming is noted at certain times of the year, and I was only able to gather specimens of the rock without determining definitely the manner of its occurrence.

Occurrence of the Rocks of the Leucite Hills.

Inasmuch as Professor Kemp has so recently presented a general sketch of the Leucite Hills, together with illustrations from photographs and an outline map of the region, I shall in the main content myself in the following pages with some details in regard to the portions of the area visited in which the rocks to be described were found.

The mesa.—The principal area of leucite-bearing rocks is in a low, irregular mesa of perhaps 15 square miles in extent, bounded by a scarp usually not more than 50 feet in height, representing the surface flow of the leucite rock resting, for the most part, on upper Cretaceous strata. On the north and northeast of this mesa are several isolated hills, flat-topped, with scarps, which were once connected with the principal mesa. Of these outlying hills only two were visited, namely, Orenda Butte and North Table Butte.

This mesa, caused by the leucite-bearing lava, has a gently undulating surface of bare rock in many places, with scanty vegetation here and there, the sage bush being most common. Several small cones rise above the mean level. There are six of these cones, according to Kemp, who gives illustrations of some of them in his paper. On the eastern side of the mesa, in one of the indentations, is a spring, known to my teamster and to the stockman who lived there as the "15-mile spring." Kemp refers to it as "the spring 10 miles from the railroad at Almond Station." In the vicinity of this spring, which was my headquarters and where the specimens for the Educational Series were collected, the lava of the scarp is somewhat variable in texture, the greater part being vesicular in some degree, with massive rock occurring here and there. It is in regard to the relation between this massive variety, which corresponds most closely to the type described by Zirkel, and the porous form, that my field observations are unfortunately so imperfect. But little of the massive rock was seen, and then nothing was observed to indicate that the two types belonged to different flows. On this account, and from the chemical identity of the two rocks, I am at present inclined to regard the leucitite of Zirkel's report as a part of the same flow that is predominantly a more or less vesicular sanidine-leucite rock, described in succeeding pages as *orendite*.

I did not explore the mesa except near the eastern end, where the rock of the surface was markedly porous and in places nearly a pumice. Two of the cones were visited, and my notes record that these consisted mainly of pumice. This statement is at variance with that of Kemp that all these cones are of solid rock and due, in his opinion, to the welling-up of lava above volcanic conduits. It is of course possible that the cones are not all of the same character.

Outlying buttes.—North-of-east and about two miles from the mesa is an outlier, known as Spring Butte to my local authorities, but described by Kemp as Orenda Butte, a name also found on the Land Office map. The inclusions noticed in the lava at this point will be specially described in a later section.

A few miles north of the principal mesa is a remnant of the former sheet in what is known as North Table Butte. We visited this point, reaching the summit through a cleft in the scarp on the northern side. The butte rises about 750 feet above the valley at its northern base, but only some 50 feet of lava is present. The rocks of the scarp vary as in the mesa to the south, but are lighter colored. Pumiceous material was found on the top of the butte. Its summit is considerably above the level of the mesa to the south, but whether this is

due to original unevennesses of the surface upon which the lava was poured out, or to subsequent faulting, was not ascertained. In the depression between this butte and the principal mesa two or three small cones were seen, each with a vertical column of rock rising from its apex. It is to be inferred that these are volcanic plugs, similar to the Boar's Tusk, shortly to be described.

Occurrence of potash nitre.—On the eastern side of the gap through which the top was gained, a cavity or recess with overhanging roof, of irregular shape, several feet in length and depth, was found in nearly massive rock. It was fully exposed to the prevalent northwesterly breeze, and rain could penetrate to the inner wall only when driven by very strong winds. In this sheltered space was found a very unusual mineral in a rather coarse, granular aggregate, and of sufficient mass to allow collection of specimens several inches in diameter. It seemed to occur as a partial crust to the cavity and as a filling for irregular fissures which extended downward and backward into the body of the rock. A columnar mass several inches in diameter connected roof and floor of the recess at one point where they were not less than one foot apart. Fragments of rock were attached to the column, and its stalactitic shape is probably an accident. This white granular substance was analyzed by L. G. Eakins and found to be essentially nitrate of potash. The exact result is given below:

Analysis of nitre, etc.

K_2O	44·91	= 96·40 nitre.
*N_2O_5	51·49	
CaO	1·09	= 3·31 gypsum.
SO_3	1·59	
H_2O	·63	
Na	·07	= 0·16 halite.
Cl	·09	
	99·87	

It is regretted that the nature of this substance was not recognized in the field, in order that closer observations of its occurrence might have been made. As far as known there is nothing to indicate the derivation of this nitre from organic substances of any kind, yet such an origin is either evident or assumed as probable for all other occurrences of natural nitrates of which I find mention in manuals of mineralogy. This occurrence is, however, entirely different from all others of which notice has been found in literature. While extended

* N_2O_5 calculated for K_2O.

discussion of the genesis of this deposit of nitre is at present useless, it may well be pointed out that ammonia gas is a common exhalation product of volcanoes in their fumarolic stage, and that ammonium chloride, salammoniac, is deposited in clefts, fissures, or tubular cavities of lavas at Vesuvius, Ætna, Solfatara, Hecla, and other volcanoes. The lavas of the Leucite Hills contained fluorine, chlorine, and sulphurous compounds, as will be shown by the rock analyses, and it is certainly a noteworthy coincidence, if nothing more, that one of the best known occurrences of salammoniac is in the leucitic lavas of Vesuvius, rich in potash.

As regards the occurrence of North Table Butte, there is no special reason to assume a volcanic conduit at this point, yet this occurrence would seem to suggest such a channel at no great distance.

Other minerals were not seen in this cavity, the nitre being deposited directly on the rocks. The presence of soda-nitre at the Boar's Tusk, described below, renders this occurrence all the more interesting. Although the nature of the nitre was not definitely recognized at the time of its discovery, the peculiar astringent taste was noted then and the true character as a nitrate was speedily established. Specimens of this nitre may be seen in the National Museum.

The Boar's Tusk.—Northwest of the Leucite Hills, in the valley of Killpacker Creek, about 20 miles north of Rock Springs, there is an interesting volcanic plug known as the Boar's Tusk, a column of leucite rock rising about 300 feet above the valley. Débris and the Eocene sandstones pierced by the plug form a cone reaching to nearly half the height on all sides. An outcrop of horizontal sandstone is to be seen near the base of the cone. Seen from the east or west the Tusk is broader and much less regular than in the view from the south.

The mass of the column is partly a compact breccia and partly massive rock. On the southern and western sides is a breccia made up of the same rock type which in massive form reaches to the top of the column on the east and north, and is apparently separated from the breccia by fissures. The breccia is coarse or fine-grained, containing fragments several feet in diameter. The principal component is always the leucite rock, but mingled with it are numerous fragments of sandstones, clays baked very hard, oolitic limestone, shell limestone, and a coarse-grained feldspathic rock.

In several places where the breccia was open and cavernous a scanty white coating was observed on protected rock faces. Unfortunately the character of this substance was not suspected, and only a single small specimen was with difficulty

procured for analysis. It proves to be soda-nitre containing a little potash, as shown by the analysis below, made by L. G. Eakins:

Analysis of soda-nitre.

Na_2O	32·09	87·98 $NaNO_3$.
K_2O	4·97	10·66 KNO_3.
N_2O_5	61·58*	
CaO	·24	0·71 gypsum.
SO_3	·33	
H_2O	·68	·54 water.
Cl	trace	
	99·89	

The discovery of soda-nitre in anything resembling this occurrence has not been announced before, as far as I can ascertain. The similarity in the conditions of occurrence of the two nitrates described above adds to the strength of the hypothesis that both are intimately related in origin to the peculiar magna of this region. Yet it is possible that organic matter from clefts above inhabited by birds or small animals might have furnished the nitrogen for this nitre.

The rock of the Boar's Tusk is nearly identical with the massive variety of the Leucite Hills, and the conclusion seems unavoidable that the Tusk is a plug occupying one of the conduits through which the potash-rich magna rose to the surface.

Wyomingite.

From the Leucite Hills proper.—The only rock type from this locality described by Zirkel or Emmons is, according to the experience of both Kemp and myself, much less abundant than the next variety to be discussed. From reasons to be more fully presented later on, I believe that this rock should receive a special name, and hence it is proposed to call it *wyomingite*, from the State in which it occurs. Although this original type has been described in some detail by others, it seems best to discuss it still more fully in this place in connection with the allied rocks, particularly since this special name is proposed for it. It is a massive rock, of a peculiar, dull reddish-gray tone, exhibiting a marked schistosity through the nearly parallel arrangement of the abundant, small, reddish mica flakes. This mica, which is the only megascopically recognizable constituent, is developed in very thin hexagonal or rhombic plates† which, under a hand lens often show a

* Calculated for $Na_2O + K_2O$.

† Zirkel says that the mica does not occur "in six-sided or rounded plates, but in the form of remarkably long stripes and dashes, such as have seldom been observed." In all the rocks of the Hills which I have examined the mica presents a more or less distinct crystal form.

delicate play of colors. The largest leaves are only 2^{mm} or 3^{mm} in diameter, and while some are of microscopic size, none belong properly to the groundmass, which consists of leucite and diopside, with but small amounts of apatite and other variable elements to be mentioned.

The mica is of remarkably weak absorption and pleochroism, the latter ranging only from a pale salmon-pink to pale yellow. Basal sections show the exit of a negative bisectrix and an optic angle which is large for mica, reaching about 35° according to a measurement made by Prof. L. V. Pirsson, who has described a very similar mica in one of the leucite rocks of Montana. Sections normal to the base often exhibit a polysynthic basal twinning, and by this means one can readily establish the fact of a measurable angle, reaching as much as 3°, between *a* and *c*. Inclusions, excepting a few of glass, are very rare in these mica plates, and pure material for chemical analysis was procured with the Thoulet solution by W. F. Hillebrand, who analyzed it with the result to be given later on. From the analysis it is plain that this mica is a phlogopite, and as far as I can ascertain it is the first definitely known occurrence of this variety in true igneous rocks. Both Zirkel and Kemp have alluded to the peculiar character of this mica, which they called biotite.

The groundmass holding the phlogopite crystals is largely made up of leucite, with many very small pale-green or colorless microlites of diopside between them. In all the sections I have examined the number of leucites with distinct crystal planes is very small compared with the multitude of minute roundish anhedra. Those individuals with icositetrahedral form are slightly larger than the anhedra, and they are further distinguished by a zone of minute inclusions and often by reentering angles on the planes of the crystal, this being the nearest observed approach to a skeleton development. The roundish grains usually vary between ·01^{mm} and ·05^{mm} in diameter. No trace of double refraction has been seen.

A variability in the development of leucite in different places is indicated by the description of Zirkel, who refers to the sharp crystal form of each of the minute individuals. From the comparatively low amount of sulphuric acid in the rock, it seems that but little noselite can be assumed to be present, although it must be developed quite abundantly in the similar rock of the Boar's Tusk, and is there indistinguishable from leucite.

The microlites of the typical wyomingite are for the most part too minute for certain identification except by comparison with the few larger ones and with the very distinct diopside of other rocks to be described. From the amount of phosphoric

acid found by analysis, these rocks are shown to be richer in apatite than would be inferred from microscopical examination. The apatite is seen occasionally in rather large grains, but must be chiefly developed in small prisms difficult to distinguish from diopside needles.

By the close crowding together of the leucites and the occurrence of diopside needles between them, it would seem as if there could be very little glassy base present; but in places there is a filmy globulitic substance between the leucites, and as will appear from the discussion of the chemical analyses, there are grounds for supposing that there must be a highly siliceous residue in the form of a colorless glass forming a base for the minute crystals. Careful reëxamination of this rock, after the difficulties in interpreting the analyses were fully shown, convinces me that there is a much larger amount of residual glass between the minute leucites and the felt of diopside and apatite needles than was at first suspected. The leucites do not often interlock with angular projections, and although the diopside needles fill in the gaps to a large degree, there is some glass undoubtedly present.

The dense wyomingite of the above character undoubtedly grades with all intermediate stages into the rock containing much sanidine, but several specimens were collected showing no feldspar except in a somewhat questionable interstitial form. Probably all thin sections exhibit a few minute leaves of dark-brown biotite containing so much ferritic matter, seemingly a product of magmatic resorption, as to obscure the optical properties. Kemp mentions a few grains of haüynite: magnetite, titanite, pyrite, and other accessory minerals seem entirely wanting in the pure wyomingite.

Both Zirkel and Kemp have represented the microstructure of this rock, and their descriptions agree with the above in most particulars. Chemical analyses of the wyomingite will be given in a later section of this article, together with those of the other types and a discussion of the systematic position of all the rocks described.

From the Boar's Tusk.—The specimens of massive rock from this volcanic neck are much like the type already described, with a slightly larger amount of phlogopite and a still more pronounced schistose structure than was observed at any point in the Leucite Hills proper. The groundmass is, as a rule, of a more or less distinct dull-greenish shade, and there are some flat, drawn-out vesicles, rarely containing any secondary minerals.

The breccia in the southern part of the neck is chiefly made up of wyomingite fragments less than 2 inches in diameter, and they seem to all belong to the same variety as the massive

rock. The matrix is a finer dust of the same origin, and it is generally pale-green in color. Fragments of sandstone, limestone, oolite, and some granular rocks rich in dark silicates were observed.

Microscopical examination reveals leucite, diopside, and phlogopite as the important minerals, with a few small biotite leaves and apatite in unusually large prisms, with axial inclusions. Both leucite and diopside are developed in much more distinct crystals than in the preceding rock. A few large irregular grains of augite and phlogopite intergrown seem probably to belong to some of the rocks appearing in fragments.

Leucite is developed in well-formed crystals which include many minute diopside needles. They reach ·05^{mm} in diameter and are very abundant, exceeding all other constituents in amount. Diopside occurs in short, colorless prisms, seldom twinned, of hexagonal cross-section through the suppression of one pinacoidal plane.

These constituents lie in a very subordinate cloudy-gray base, which obscures the leucites except in the thinnest places. By high powers a faint greenish color seems visible, and as there is some double refraction in the mass it appears probable that there is a microlitic development of diopside and a scanty glass base. No magnetite was seen in the rock.

Orendite.

The principal rock of the Leucite Hills, whose chief constituents are leucite and sanidine, with phlogopite, amphibole and diopside, seems to me worthy of a special name, and it is proposed to call this rock and its equivalents elsewhere *orendite*, after the prominent butte on the northeastern side of the Hills, where it is well developed. The reasons for this proposition and the scope of its suggested application are presented fully in a subsequent section, after discussion of the chemical analyses.

Megascopical description.—The orendite is characterized by the same dull reddish-brown or gray tones seen in the wyomingite, and its only distinct megascopic constituent is phlogopite. All the specimens collected were subordinately vesicular, but that is of course not an essential feature. On North Table Butte the rocks are much lighter in color than was observed elsewhere, being yellowish to straw-colored. Under a lens the mass of the rock seems almost saccharoidal in texture, showing a white granular mass colored by a small amount of indistinct pinkish or yellowish matter.

In most cases a few dull grains of orthoclase will be seen, but they are corroded and show the same character as the feldspar of larger included rock fragments to be described later. These are therefore not regarded as phenocrysts properly

belonging to the rock. By close examination under a lens small glistening cleavage surfaces may occasionally be seen, which are interrupted by many minute particles, producing a poikilitic structure. These surfaces belong to sanidine.

The pores of the rock are always irregular in shape, ordinarily not drawn out in any prevalent direction, showing divergent smooth-walled arms. They vary from 1^{cm} in length downward, and are also developed in variable amount. In some places the cavities constitute half the bulk of the rock.

With a hand lens of high power the walls of the cavities are often seen to be coated by a network of very pale-yellowish needles, and in rare cases they project free into the pores. These needles are of the amphibole described below. A far more common filling of the pores is hyalite, in its characteristic clear globular forms. With the hyalite, and generally embedded in it, is a white mineral in rude bundles, opaque, and so poorly developed that it has not been determined.

Mineral constitution and structure.—On microscopical study it is found that this rock consists of leucite and sanidine in predominant amount as compared with the ferro-magnesian-lime elements, phlogopite, amphibole and diopside. Apatite and rutile (?) are accessory minerals, but no magnetite, ilmenite or pyrite occurs. Biotite is developed, as in the wyomingite, in a few much resorbed flakes. It is probable, from examination of the chemical analyses, that free silica in the form of tridymite or opal is present, but aside from the filling of cavities spoken of above neither substance has been identified.

In quantitative development leucite and sanidine vary considerably, now the one, now the other seeming to predominate, but in general they are nearly equal in amount. Of the heavier silicates phlogopite is the most important, while the other two seem to vary with the leucite and sanidine. The amphibole is developed approximately in proportion to the sanidine, and diopside corresponds to leucite. No amphibole has been found in the sanidine-free wyomingite.

The peculiar association of minerals in these rocks leads to several interesting microstructures. Phlogopite appears to have formed first and is almost wholly free from inclusions. Leucite and sanidine are as a rule grouped in separate patches or areas, the former in swarms of minute anhedra exactly like those of the wyomingite. Sanidine occurs in aggregates of stout, square prisms, much larger than the leucites, but still seldom exceeding 1^{mm} in length.

Diopside is mainly developed in minute needles and microlites, a large share of which are included in the sanidines, producing a poikilitic structure which may occasionally be detected megascopically. The remainder of the diopside occurs

between other grains, and the leucites are almost free from inclusions.

The amphibole seems to be the last mineral to form, and it varies in development. In the angular spaces between the sanidines the yellowish amphibole occurs exactly as does augite in the ophitic diabases, while in the leucitic areas the same amphibole is developed in stout prismatic anhedra enclosing the leucites, just as ægirine or ægirine-augite does the nephelites in many phonolites. In occasional spots and adjacent to the pores of the rock the minerals are less intimately intergrown. Leucite is sometimes found included in sanidine, but more frequently the separation is very sharp.

There are thus in this rock two kinds of micropoikilitic structure, a curious separation of the analogous silicates, leucite and sanidine, and a porphyritic structure through the prominence of phlogopite leaves.

Sanidine.—The glassy feldspar of this rock was mentioned by Kemp, who noted a rare development of simple twinning and an extinction reaching a maximum of 10° from the length axis. The rude crystal form renders accurate orientation difficult, but since my own observations agree with Kemp's as regards the angle of extinction, and as it is always the axis *a* of elasticity which lies near the longer axis of the crystal, it seems proper to interpret these prisms as developed parallel to the clinoaxis. As the terminal faces of such crystals are commonly domatic planes, the prevalent rectangular outlines are explained. The twinning observed must be after the Carlsbad law, as extinction is parallel to the twinning plane.

No microscopic intergrowths with other feldspars have been seen, a natural consequence of the low soda contents of the magma. Cleavage is seldom well marked, a fact which may be due in part to the multitude of microlitic inclusions, serving to hold the cleavage plates together as in the mica of the Pilot Butte rock (p. 128).

Amphibole.—Kemp does not mention the presence of amphibole in the rocks described by him, which are otherwise like the orendite. It is indeed very variably developed in my sections, some 40 in number, and is not often seen in prisms well adapted for study. In its optical characters this amphibole is unlike any of which I can find record. Its general determination as an amphibole rests upon the strong cleavage parallel to a prism of about 124° and the observed habit of the mineral.

While usually irregular in outline, a few cross-sections have been found which agree with amphibole in the angles of the prism, cleavage, and existence of pinacoidal planes. The terminal planes are very rarely developed, and then seem to be pyramid and dome.

The optical properties are unlike those of any mineral with which I am acquainted. Extinction seems to be always parallel to the length axis. The optical scheme is as follows:

$a=a$, pale yellow; $b=b$, red; $c=c$, bright yellow. The reddish tones are very similar to those of hypersthene and increase rapidly in intensity with increasing thickness. Absorption: $b>c>a$.

Needles scraped from the cavities have the same character as the embedded mineral. In the powder obtained from one cavity there was found a flake apparently representing a section normal to the prism as indicated by cleavage, prism angle, and pleochroism. Examination of this plate in convergent polarized light showed the figure of an almost uniaxial mineral, the arms barely separating in the 45° position.

Other constituents.—Phlogopite and leucite are so identical in development with the forms described for the wyomingite that no further comment is necessary. Apatite appears in a number of clear, more or less irregular prismatic grains, with axial inclusions; but the analysis indicates a much larger amount of this mineral in the rock than one would infer from the sections. The mineral mentioned above as rutile (?) occurs in minute yellow needles of round prism outline, with strong single and double refraction and extinction apparently parallel to prism, though absorption in this direction is so strong as to obscure extinction.

The Rock of Pilot Butte.

Occurrence.—In the words of Mr. Emmons,* "Pilot Butte is a curious little conical castle-like mound, rising about 400 feet above the surface of the plateau country, in the angle between Bitter Creek and Green River to the north of the [Union Pacific] railroad. It is a rudely circular mass, scarcely 1000 yards in diameter, having abrupt faces on all sides, and composed of a rather singular volcanic rock unlike any other found within the limits of the survey. It is evident that the soft Green River [Eocene] Tertiaries, which once surrounded and covered it, must have been eroded away. . . ."

The plateau above which the butte rises is separated from the principal mesa of the Leucite Hills by the broad shallow valley of Killpacker Creek, and no other mass of volcanic rock is known nearer than the Leucite Hills, some 15 miles to the eastward. No observations are reported by either Emmons or Kemp indicating beyond question the character of this mass. No contacts seem to have been found. At the eastern base, where I gathered my material, talus effectually concealed the contact, and such may be the condition on all sides.

* Reports of the Fortieth Parallel Survey, vol. ii, Descriptive Geology, 1877, p. 238.

In view of the somewhat porous texture, the fluidal structure, and the presence of a glassy base in the rock of Pilot Butte, it is most plausible to regard the mass as a remnant of a surface flow.

Description.

Megascopical appearance.—In general the megascopical descriptions of the Pilot Butte rock given by Emmons and Kemp in their cited publications apply to my own material. The rock is ashen-gray, yellowish, or greenish, and generally porous in a subordinate degree. As the pores of the gray rock are almost free from secondary minerals, while those of the yellowish variety contain white minerals of zeolitic character, the former seems probably the normal color of the fresh rock. The pores are small, very irregular in form, and are but slightly drawn out in any direction. The fractured faces are quite rough and uneven.

To the unaided eye the rock is largely dull and felsitic, with numerous small reddish specks showing strong cleavage. These are somewhat less than 1^{mm} in diameter, and all belong to phlogopite. The uniform distribution of these mica grains is very noticeable in all specimens I have seen. Occasional smooth surfaces, when examined by a hand lens, show minute pale-green prisms in a network. These are doubtless diopside, the principal constituent of the rock.

Constitution.—On microscopical examination it appears that colorless diopside, phlogopite, and probable perofskite, are the chief minerals of this rock, with a glassy base of brownish color, which according to the analysis must contain silica, alumina, and the alkalies in nearly the proper ratio to have caused the formation of leucite had the mass entirely crystallized.

The development of diopside in this rock is very similar to that described for the same mineral in the wyomingite of the Boar's Tusk. It appears in colorless, doubly terminated prisms less than 1^{mm} in average length, more or less markedly arranged in streams. Cross sections show common development of the prism and orthopinacoid, and occasional twinning parallel to this latter plane. An analysis of diopside is to be given later on.

The next most important mineral is mica, which is very similar in many respects to that in the rocks of the Leucite Hills, but exhibits certain peculiarities of development worthy of notice. Instead of being well crystallized and free from inclusions, as in the other types, the phlogopite of the Pilot Butte rock occurs in roundish grains averaging $0{\cdot}8^{mm}$ in diam-

eter, holding the diopside microlites and perofskite grains in as great numbers as does the residual glass. The streams of diopside prisms pass without any change through the phlogopite grains, and a very pronounced form of the micropoikilitic structure is thus produced. The anhedra of phlogopite have very uneven, ragged outer borders, and show none of the usual tendency to develop in plates parallel to the cleavage, and this parting is here much less strongly developed than in any other occurrence of mica known to me. The cleavage lines appear in this case like those in feldspar or amphibole, being sharp and clear, but by no means so numerous as is usual.

That this peculiarly developed mineral is mica seems to me sufficiently established by the following data: The color is almost identical with that of the phlogopite. Sections showing strongest cleavage polarize very brilliantly and extinguish parallel to the cleavage, as far as can be ascertained. The brilliant polarization of most sections is very striking, but a few may be found where the maximum color is the pale-blue of melilite. Such sections show in convergent light the exit of a negative bisectrix, the optical angle being large. The plane of the optical axes is parallel to a sharp boundary line which was observed in one case. The pleochroism is even fainter than in the mica of the leucite rocks, but by comparing the sections showing best cleavage with those exhibiting the optical figure the following optical scheme was made out:

a yellow, with pinkish tinge occasionally, lies normal to the cleavage, i. e. near *c*.
b pink, parallel to *b*.
c straw yellow, nearly parallel to *a*.

This orientation is the same as that of the phlogopite in the leucite rocks.

Perofskite and magnetite are developed in minute crystals of 0·02^{mm} to 0·03^{mm}, and the former is much the more abundant. The grains referred to perofskite are roundish crystals of very high index of refraction, yellow-brown color, isotropic, and only those included in the phlogopite are entirely fresh, the rest showing a dull white cloudy alteration product which causes them to stand out in marked contrast to the magnetites when the section is viewed by reflected light. Some very minute needles of apparently yellowish color may be seen in the phlogopite, with a high power. These seem most plausibly referred to rutile, though no regular arrangement was observed.

The glass base of the rock is isotropic but not clear and transparent, being clouded by indistinct globulites and microlites which seem to have a yellowish-green color, or at least

that is the tone of the mass where they are developed. Nearly one-third of the rock is amorphous, but the multitude of minute crystals embedded in it, the cloudy zone about the perofskites, and the globulitic particles mentioned, make this base transparent only in the thinnest sections. As will be shown later on, this glassy base contains silica, alumina, and the alkalies, in nearly the ratio found in leucite.

For this rock, consisting of diopside and phlogopite in predominant degree, and with leucite or a glassy base corresponding to it, I propose the name *madupite*, from the Shoshone Indian *madúpa*, meaning sweetwater,* the name of the County in which the locality is situated. A definition, with discussion of the relationships of madupite, will be found in a later section of this article.

Chemical Composition of the Rocks Described.

In the table below are given several analyses of wyomingite, orendite and madupite, of the phlogopite and diopside isolated from these rocks, and of a few related rocks for purposes of comparison. Under I is an analysis by Pawel, made for Zirkel† and published in his German résumé of the 40th Parallel report; II is by R. W. Woodward, and was published by Emmons‡ (I and II were presumably made on the same material); III is of wyomingite from the Boar's Tusk; IV of wyomingite from the 15-mile spring; V is of orendite from the 15-mile spring; VI of orendite from North Table Butte; VII of madupite from Pilot Butte; VIII of phlogopite from wyomingite of Boar's Tusk; IX of diopside from wyomingite and madupite. The analyses III to IX, inclusive, are all by W. F. Hillebrand, whose many painstaking and reliable analyses of igneous rocks form a most important contribution to petrography. Analysis X, by H. N. Stokes, is of "leucitite" from the Bearpaw Mountains, Montana, described by Weed and Pirsson (this Journal (4), vol. ii, 1896, p. 147). No. XI, by E. B. Hurlburt, is of missourite, also from the Highwood Mountains and described by Weed and Pirsson (this Journal (4), vol. ii, 1896, p. 321).

* According to information kindly given me by Mr. W. J. McGee, of the Bureau of Ethnology.

† Ueber die Krystallinischen Gesteine längs des 40ten Breitegrades in Nordwest-Amerika. Berichte der k. sächs. Gesellschaft der Wissenschaften, Jan., 1877, p. 239.

‡ Reports of the Fortieth Parallel Survey, vol. ii, Descriptive Geology, 1877, p. 237.

TABLE OF ROCK ANALYSES.

	Wyomingite.				Orendite.		Madupite.	Phlogopite.	Diopside.	Leucitite, Montana.	Missourite, Montana.
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.
Sp. Gr.			2·779 13° C.	2·627 30° C.	2·686 23° C.	2·699 19° C.	2·857 22° C.		3·290 20° C.		
SiO_2	56·30	54·42	50·23	53·70	54·08	54·17	42·65	42·56	50 86	46·51	46·06
TiO_2	----	----	2·27	1·92	2·08	2·67	1·64	2·09	*a*3·03	·83	·73
ZrO_2	----	----	----	----	----	·22	----	----	----	----	----
Al_2O_3	12·63	13·37	11·22	11·16	9·49	10·16	9·14	12·18	none	11·86	10 01
Ce_2O_3	} ----	----	·03	none	?	----	·11	----	----	----	----
Di_2O_3	}										
Cr_2O_3	----	----	·10	·04	·07	·05	·07	·73	----	none	----
Fe_2O_3	} 6·92	·61	3·34	3·10	3·19	3·34	5·13	2·73	1·19	7 59	3·17
FeO	}	3·52	1·84	1·21	1·03	·65	1·07	·90	1·82	4·39	5·61
MnO	----	----	·05	·04	·05	·06	·12	----	·03	·22	tr.
CaO	5·63	4·38	5·99	3·46	3·55	4·19	12·36	·20	23·32	7·41	10·55
SrO	----	----	·24	·19	·20	·18	·33	----	----	·16	·20
BaO	----	----	1·23	·62	·67	·59	·89	1·00	----	·50	·32
MgO	5·08	6·37	7·09	6·44	6·74	6·62	10·89	22·40	17·42	4·73	14·74
K_2O	11·50	10·73	9 81	11·16	11·76	11·91	7·99	10·70	·42	8·71	5·14
Na_2O	2·21	1·60	1·37	1·67	1·39	1·21	·90	·44	·76	2·39	1·31
Li_2O	----	tr.	tr.	tr.	tr.	tr.	tr.	tr.	----	----	----
H_2O (*b*)	----	2·76	·93	·80	·79	·52	2·04	} 2·35	·31	1·10	} 1·44
H_2O (*c*)	----		1·72	2 61	2·71	1 01	2·18	}		2·45	}
P_2O_5	----	----	1·89	1·75	1·35	1·59	1·52	·06	----	·80	·21
SO_3	----	----	·74	·06	·29	·16	·58	----	----	tr.	·05
Cl	----	----	·03	·03	·04	·06	·03	----	----	·04	·03
Fl	----	----	·50	·44	·49	·36	·47	2·46	----	tr.	----
CO_2	----	1·82	----	----	----	·49	----	----	----	----	----
	100·27	99·58	100 62	100·40	99·97	100·21	100·11	100·80	99·16	*d*99·73	99·57
O for Fl	----	----	·22	·19	·21	·17	·20	1·03	----	----	----
	----	----	100·40	100·21	99·76	100·04	99·91	99·77	----	----	----

a. TiO_2 and P_2O_5; *b* = below 110° C.; *c* = above 110° C. *d*. With ·04 NiO. No. VI contains a trace of nickel.

Discussion of analyses.—It is interesting to note that the older analyses, in spite of the evident inaccuracies, indicate quite correctly the general character of the magmas of the Leucite Hills; but they fail to show the great complexity of constitution which makes these rocks so noteworthy. Few rocks have been shown to contain so many chemical elements in determinable amounts; and in this connection it should be stated that in all probability zirconia was present in all the rocks, but was not tested for in the older analyses, III, IV, V, and VII, which were made several years ago, while VI was made in January, 1897.

From the analyses of phlogopite and diopside it is plain that TiO_2, Cr_2O_3, BaO, and Fl are in very large degree contained in the mica, while the first is the only one of these oxides in the diopside. Tests showed that the sulphuric acid was always in the part of the rock soluble in HCl, hence it is certain that barite cannot be present, and the probability appears that noselite is developed to a varying extent in minute crystals not distinguished from leucite in the thin sections. There is an unusually large amount of P_2O_5 in all these rocks, and while a few large apatites may be readily detected under the microscope, it seems probable that much of this mineral is developed with diopside in minute needles not easily recognized. The presence of such a large amount of phosphoric acid here contrasts in a noteworthy manner with the very small amount ordinarily found in phonolites.

It is noteworthy that the rock of the volcanic neck (III) is richer in almost all of the rarer constituents than any other except that of Pilot Butte. It is also higher in magnesia and lower in silica than the others. As for zirconia the suggestion is made that the peculiar amphibole of orendite is perhaps zirconia-bearing, analogous to låvenite, wöhlerite, and hiortdahlite. If that is the case it seems quite possible that the amphibole contains Ce_2O_3 and Di_2O_3.

The most striking fact of petrographical interest in these analyses is the almost identical constitution of two rocks, one rich in leucite and free from sanidine, the other with predominant sanidine. The conclusion that chemical composition of a magma does not alone determine whether leucite or sanidine shall be formed, but that this is controlled by conditions of consolidation is unavoidable. As the composition of the amphibole in the orendite is unknown, a satisfactory calculation of analyses V and VI is impossible, but those of the other types afford interesting results.

Taking first the Boar's Tusk wyomingite, the molecular ratio of its constituents is as below; and on assuming that lime is wholly in apatite and diopside, magnesia in diopside and phlo-

gopite, these elements may be calculated out, leaving only silica, alumina and the alkalis in considerable amounts. Alumina is found to be insufficient to combine with the alkalis in leucite or sanidine, but if the SO_3 is present in noselite the alumina is almost exactly sufficient. There is a large excess of silica, enough indeed to have formed sanidine with all the alumina and alkalis.

CALCULATION OF ANALYSIS III.

Molec. ratio.		Diopside.	Phlogopite.	Noselite.	Leucite.	Apatite.	Residue.
SiO_2	837	132	127	54	252		272
TiO_2	28	4	5				19
P_2O_5	13					13	0
SO_3	9			9			0
Al_2O_3	110		20	27	63		0
Fe_2O_3	21	1	2				18
FeO	26	4	3				19
CaO	107	64				43	0
MgO	177	68	109				0
K_2O	104		23	14	63		4
Na_2O	22			22			0
	1454	273	289	126	378	56	
			19·87 %	8·66 %	26·1 %		

Neglecting the small amounts of substances shown by analysis and not introduced into the above calculation, this rock consists of

Free silica	18·7	
Leucite	26·1	53·5
Noselite	8·7	
Diopside	18·8	
Phlogopite	19·9	
Accessories	7·8	
	100·0	

The residual amounts form a little magnetite, and there is some titanic acid which may belong to silico-titanates or be present as rutile. The silica is more than enough to have formed sanidine instead of leucite if the conditions had been favorable.

It is plain that a rock containing leucite, with diopside and phlogopite of the ascertained composition and in the observed proportions, cannot have so high an amount of silica without containing an excess of the acid radical unless some very acid silicate is present. The only possible explanation of the ascertained chemical composition, without assuming free silica, is in supposing that the apparent leucite is a regular mineral of higher silica contents than leucite, with the ratio of alumina

to potash the same. By the calculation of the Boar's Tusk rock it would seem necessary to assume that the hypothetical mineral had the composition of orthoclase. No such mineral being known, this hypothesis would quickly lose all suggestion of support were it not for the results derived from a calculation of the analysis IV.

CALCULATION OF ANALYSIS IV.

Molec. ratio.		Apatite.	Diopside.	Phlogopite.	Leucite.	Residue.
SiO_2	895		76	144	348	327
TiO_2	24		2	6		16
Al_2O_3	109			22	87	0
Fe_2O_3	20			3		17
FeO	17		2	3		12
CaO	71	39	37			0
MgO	161		39	122		0
K_2O	119			25	87	7
Na_2O	27					27
P_2O_5	12	12				0
			10·7 %	22·3 %	35·7 %	

The calculation shows a marked excess of the alkalis and a very large one of silica. In this case the sulphuric acid is so low as to be of little effect upon the calculation in assuming it to represent noselite. Here, then, as before, there is an apparent excess of silica which cannot be discovered in the rock in the form of opal, tridymite, or quartz, and the excess of alkali is equally difficult of explanation. Alumina cannot be assumed as too low by error of analysis, as the analyses are quite consistent in this respect and repeated determinations have yielded almost identical results, as also in the case of SO_3.

Acting upon the suggestion that the apparent leucite of these rocks might possibly have a different composition from the normal, Dr. Hillebrand treated the powder of the wyomingite yielding the result under IV with dilute nitric acid (1 acid to 40 water) and found in solution the following:

		Molec. ratio.
SiO_2	6·08	101
TiO_2	·21	3
Al_2O_3	·91	9
FeO*	·50	
CaO	2·13	38
SrO	·10	
BaO	·14	
MgO	1·51	38
K_2O	1·21	13
Na_2O	·28	4
P_2O_5	1·54	11
	14·61	

* All iron as FeO.

The CaO is almost exactly what is required for P_2O_5 in apatite, hence the soluble magnesian silicate must be phlogopite. But if the requisite amount of alumina be taken to form phlogopite on the basis of the magnesia, there remains but a trace of alumina to combine with the residue of the alkalis in leucite or any other mineral; and even if leucite should first be calculated out, assuming all the alumina to be in that mineral, there would remain a considerable residue of the alkalis. Silica is here, too, in excess of the requirements to form any known rock-making silicate with the bases in solution.

While a calculation of the analyses of orendite is impossible without knowing the composition of the peculiar amphibole, yet the difficulty of accounting for the alkalis found is even greater than in the wyomingite, because both analyses show less alumina and more alkali than before. The relation of alumina to alkali is much less than 1:1, whereas in all the important alkali-bearing silicates of rocks that ratio holds good.

A comparison of analysis VII with the preceding ones shows that the madupite is even more closely related to the type of the Leucite Hills than might be suspected from the similar developments of the pyroxene and mica in the two cases. This similarity alone led Kemp to correctly characterize the Pilot Butte type as "clearly a variant from the group of rocks of the Leucite Hills." In the presence of the rarer elements, Ce_2O_3, Di_2O_3, Cr_2O_3, SrO, BaO, SO_3, Fl, Cl, and in the ratio between potash and soda this magma certainly shows blood relationship —consanguinity—with the magmas of the Leucite Hills.

CALCULATION OF ANALYSIS VII.

Molec.	ratio.	Perofskite and Apatite.	Diopside.	Phlogopite.	Noselite.	Leucite.	Residue.
SiO_2	711		346	120	42	203	0
TiO_2	21	21					0
Al_2O_3	90			17	21	52	0
Fe_2O_3	32		2	2			28
FeO	17		10	2			5
CaO	221	58	163				0
MgO	272		173	99			0
K_2O	85			20	14	51	0
Na_2O	14				14		
P_2O_5	11	11					0
SO_3	7				7		0
Fl	25			25			
	1506	90	694	285	98	306	33

From the character of the minerals developed in the madupite and the knowledge of their composition obtained through the analyses of the diopside and phlogopite, one may calculate

very closely the composition of the glassy base. Assuming that the lime remaining after deductions for apatite and perofskite is a measure of the diopside of the rock, and that the magnesia surplus after the formation of diopside is all contained in phlogopite, of the composition found in the analyses already given, there remains, after calculating out apatite, perofskite, diopside, and phlogopite, a residue of silica, alumina, potash, and soda which is almost exactly that necessary for leucite and noselite, calculating the latter from the sulphuric acid, as in the case of the Boar's Tusk wyomingite.

The result of these calculations is to indicate that if this magma had entirely crystallized, it must have had very nearly the following percentage development of the named constituents:

Diopside	46·1	65·0
Phlogopite	18·9	
Leucite	20·3	26·8
Noselite	6·5	
Accessories	8·2	
	100·0	

The amounts of phlogopite calculated from the fluorine contents of the rock and from the magnesia after deducting for diopside agree very closely. While I have been unable to detect a single grain of leucite or noselite in my sections, Kemp refers to a few very minute particles of leucite seen by him. In the calculations I have disregarded the amounts of strontia and baryta in the absence of a good basis for assigning them, although it is known that a part of the baryta is in the phlogopite.

By comparing the analysis of madupite with that of missourite, the granular augite-leucite rock recently described by Weed and Pirsson,* reproduced under XI of the table above, a marked similarity may be discovered. Missourite is richer in magnesia and poorer in lime than madupite, and it has 15 per cent of olivine with only 6 of biotite. As is well known, the quantitative relations of olivine, biotite, and leucite are quite variable in very similar rocks, and under slightly different conditions the missourite magma might have yielded more mica and less olivine and leucite. Each rock has about 50 per cent of augite or diopside, and while missourite has 37 per cent of olivine, leucite, and biotite, the crystalline madupite would have had 39 per cent of leucite and phlogopite. It is quite possible that the deep-seated granular equivalent of madupite is a near relative of missourite.

*Missourite, a new leucite rock from the Highwood Mountains of Montana. This Journal, (4), vol. ii, 1896, p. 315.

Classification and Nomenclature.

In the foregoing pages new names have been proposed for three rock types described. It is now desired to explain as clearly as possible the grounds for adding three new names to the rapidly growing list of rock varieties, and this involves more or less discussion as to principles of classification.

With regard to the present tendency to confer names upon many more or less distinct, newly recognized or more narrowly defined, rock types, it must be admitted that from several sources the protests against this course are most natural. Teachers, geologists with whom petrography is a side issue, and those to whom all rocks are merely accidental mixtures of various minerals,—to all these the new terms are abhorrent. But while a period of confusion is to be regretted, it appears to me that the recognition and naming of every truly distinct rock type may be a necessary prelude to the much needed reform of our present illogical and inadequate petrographical scheme.

Igneous magmas must be classified on chemical grounds; their crystalline equivalents principally upon mineralogical constitution, as the more or less evident expression of chemical composition and as the cause of the principal characteristics of rocks. It does not follow, as is sometimes asserted, that because rock-making minerals may be developed in infinitely varying proportions, that there are no natural rock types or groups. There is, for each prominent rock constituent, a considerable range in its development within which it places its own stamp upon the rock containing it. It may play the leading role, or share the honors equally with others, or be subordinate. With a given structure the habit of the rock depends largely upon the minerals which are its leading constituents. Most new rock names of the last few years have been conferred, consciously or unconsciously, in recognition of this natural law. But this law has not yet been fully recognized in the system of petrography, and until it is so recognized the system will be unsatisfactory. The character-giving relative abundance of minerals in rocks is not awarded proper weight in classification.

The weakness of the present scheme in the direction alluded to lies in giving to the feldspars and feldspathoids far too much weight, and to the dark silicates far too little, in constructing the frame work. "Rocks with feldspar,"—"Rocks without feldspar,"—these two divisions comprise all igneous rocks. Gabbro is mineralogically a rock composed of basic plagioclase and pyroxene, and within it are included everything from anorthosite to the vanishing point of the feldspar, and we are

even told by Rosenbusch that peridotite and pyroxenite are annexes of the gabbros.*

The fact that the names leucitite and nephelinite are currently applied to rocks in which leucite and nepheline are not necessarily of much quantitative importance, also illustrates very well the inadequate and illogical character of our present petrographical nomenclature. The natural application of these terms would be to rocks so rich in leucite or nepheline as to derive their dominant mineralogical features from the characteristics of these species. But as a fact one must search very carefully with a microscope to detect any leucite in some of the so-called leucitites.

The leucite rock described by Zirkel, to which it is here proposed to give the name *wyomingite*, has been placed in the group of the leucitites by both Zirkel and Rosenbusch in their latest systematic works, but with comments upon its exceptional character, removing it far from its nearest ally in the group. The new name is proposed for this rock in recognition of its peculiar character, and also as a part of a scheme for reclassifying the leucite rocks which it is hoped may find favor with those who have to deal with this interesting class of igneous rocks.

As a first step, in spite of established usage, I should be glad to see the term leucitite reserved for the rock that has not yet been discovered, to my knowledge, consisting essentially of leucite, with all other minerals of subordinate importance. There is good reason to believe that such rocks are possible and will be found at no distant day. The same suggestion is made for nephelinite, on the same grounds.

Following leucite would come the rock here called wyomingite, and its granular equivalent, in which leucite and its allies are of approximately equal importance with the ferromagnesian-lime silicates, and then a rock of which madupite is deemed a vitrophyric representative. Leucite-sanidine, leucite-nepheline and leucite-plagioclase rocks are known, or will be found, in which these elements preponderate, and they are certainly very different from the types from which the present nomenclature of leucite rocks has been mainly derived, where leucite is of secondary importance.

Reviewing the chemical and mineralogical characteristics of the rocks under discussion, it is evident that they are notable for their high contents in the alkalis, and especially for the strong preponderance of potash over soda; and although wyomingite is one of the richest known rocks in leucite, it is not this fact alone which gives character to it. Prominence must be given to the fact, which is also true of the sanidine-bearing orendite and of the madupite with its glassy base, that

* Massige Gesteine, 3d ed., pp. 344, 367.

the preponderance of potash has controlled the character of the ferromagnesian-lime silicates. Such rocks must be contrasted with the tinguaites, derived from magmas rich in soda, producing nepheline and alkali-feldspar, with pyroxenes or amphiboles of characteristics due to the entrance of soda and ferric oxide into the molecules.

The three rocks described belong to a series whose magmas were relatively so rich in potash that soda has not played any perceptible role in the products of crystallization. It has been prevented from combining with lime in plagioclase or with ferric oxide in the ægirine molecule. If it does, in certain rocks, go with sulphuric acid into noselite, it still fails to make itself noticeable.

Wyomingite is essentially composed of leucite, a magnesia-potash mica, and diopside, all in large quantities. Its magma was characterized, as has been pointed out, by richness in potash with low alumina and considerable amounts of magnesia and lime. Should it be demonstrated by future experience that other leucite rocks actually contain more than enough silica to have made sanidine in place of all the leucite, it may be desirable to restrict the type to such acid leucite rocks; but it seems to me at present better to disregard this excess, in definition, as quite anomalous, for the rock does not derive any observable physical characteristic from the superabundant silica.

The structure of this original wyomingite is rudely fluidal and porphyritic, but nevertheless of an intermediate, more or less confused character, best expressed, among existing terms, as hypidiomorphic. Geological occurrence is omitted from these definitions because it has to my mind no legitimate place in the purely petrographical classification of igneous rocks. The rock is known in surface masses and in a volcanic conduit near the surface. It is probable that the structure observed may extend to considerable depths. Its granular equivalent should receive another name.

Orendite was derived from the same magma as the wyomingite. It has sanidine and leucite in about equal quantities, with magnesia-potash mica and diopside as the other essential constituents. The development of a peculiar amphibole in the type of the Leucite Hills can only be regarded as a local characteristic. Orendite has in this present case a still greater complexity in structure than the wyomingite, but much of it must be considered as of local importance only. According to the nomenclature of Zirkel, the rock would be classed with the leucite-trachytes, and by that of Rosenbusch as leucite-phonolite. While agreeing with Dr. H. S. Washington* in his criticism of the term leucite-phonolite, I think that the same

* Italian Petrological Studies, I; Journal of Geology, vol. iv, 1896, p. 555.

objection applies with somewhat lessened force to the other name. If a nepheline-sanidine rock is to be called phonolite, an independent name is also appropriate and desirable for analogous leucite-sanidine rocks. As Washington remarks, a leucite-phonolite should be a leucite-nepheline-sanidine rock. And it seems to me that compound names of this character should always be used for the mineralogical varieties of a given species.

Madupite may be defined as consisting essentially of diopside and a magnesia-potash mica with leucite in decidedly subordinate amount. Its magma was low in silica, alumina and iron, rich in potash, and contained so much lime and magnesia that silicates of these bases are the principal constituents, yet controlled in their development by the strong potash element. The calculation of the analysis of madupite from Pilot Butte shows so clearly what must have been the products of its crystallization that this rock may be considered the vitrophyric equivalent of the type so defined.

As to the systematic relationships of these rocks, there is not very much to be said beyond what has already been presented in discussing their relationship to each other. No other rocks known to me approach very near to the types described. As leucitic rocks their nearest allies are some of the Italian "leucite-trachytes," in which, however, soda plays a more important role. As pyroxene-mica rocks the relation to the minettes and vogesites is most striking. In fact I think that the rocks may be effectively characterized as surface equivalents of lamprophyres containing leucite instead of feldspar, rich in potash, lime and magnesia, and poor in alumina and iron. It is to be noted that leucite-bearing camptonites and tinguaites are now known.

It is not possible to say with certainty what mineralogical composition the deep-seated portions of these magmas may have. As the recent investigations of Doelter* have clearly shown, the influence of physical conditions and of accompanying mineralizing agents, such as fluorine, is very great in just such magmas as those of the rocks under discussion. The Leucite Hills magma has very possibly yielded a sanidine rock in depth, yet the Boar's Tusk conduit, where exposed, is occupied by a leucite rock. It is difficult to see how the madupite magma, consolidated in the lower parts of its eruptive channel, can fail to contain much leucite, and if only that portion of the geological body were known, there can be little doubt that the rock would be called a lamprophyre by the German school of petrographers. If coarsely granular, it might be nearly related to missourite, as already pointed out.

*C. Doelter: Synthetische Studien; Neues Jahrbuch für mineralogie, etc. 1897, Bd. i, p. 1.

Of course to call these surface rocks lamprophyres is to disregard the fundamental conception of Rosenbusch as to the geological significance of this group of "dike-rocks." But I fully agree with Iddings,* who has discussed this question at some length, that the lamprophyres are abundantly represented at the surface by lavas differing in structure and mineralogical composition from the dike rocks, as a result of differing conditions of consolidation. The Boar's Tusk wyomingite has, moreover, a decided resemblance to minette in habit, making due allowance for the different roles played by leucite and sanidine as a result of contrasting crystal forms.

It is with great regret that I confess my inability to state the existing relationship in occurrence between wyomingite and orendite. The former is massive, the latter always vesicular, and I believe them to be merely different parts of one flow. The pumice contains neither leucite nor sanidine.

Inclusions in the Leucite Hills Rocks.

There are many inclusions of foreign rocks in the lavas of the Leucite Hills and in the Boar's Tusk. These were also noted by Kemp, who found them especially abundant in the southwestern part of the principal mesa, and who mentions sandstone as the most common type. The fragments occur in all parts of the Hills visited by my party, and many different rocks were observed: sandstone, limestone, oolite, granite, and some peculiar mineral combinations to be mentioned.

The most noteworthy feature of these included fragments is the very distinct caustic action of the lava displayed in most cases. Some quartzose sandstone inclusions are vitrified in considerable part, and certain granitic rocks have also suffered partial fusion. It is noticeable that a rounded form is common among these inclusions, but there is little or no evidence that this rounding is the result of fusion.

Rocks composed of pyroxene and plagioclase feldspar seem quite abundant, and some were found consisting almost wholly of plagioclase rich in lime. Still others are basic combinations of augite and biotite with but little feldspathic material.

The action of the magma upon these inclusions may be illustrated from a few instances. One small inclusion of rounded form appears megascopically to be a medium-grained rock of green pyroxene and feldspar, but it is noticeable that the feldspar grains are not distinct and cleavage can not be distinctly made out. Microscopical examination shows the feldspar to have been plagioclase, but it has been acted upon by the magma and partially destroyed. Along cleavage lines and on

* The Origin of Igneous Rocks, Bull. Phil. Soc., Washington, vol. xii, pp. 172–178, 1892.

the planes of albitic twinning the feldspar is in part replaced by cloudy isotropic matter leaving remnants of feldspar with somewhat weakened double refraction here and there. In some parts where no optical action can be discerned, the former twinning planes may be traced by the varying cloudiness. On the contact with the orendite containing this inclusion, the cloudy mass gives way to a clear glass. In it are apparently colorless rounded or irregular granules which seem to be diopside, though not developed in determinable form. The contact between inclusions and rock is sharp and no change in the character of the latter can be made out which might be referred to assimilation of the fused inclusion.

Augite is much less attacked than feldspar; it is often entirely unaltered in contact with the cloudy product from the feldspar. In some places the diopside grains have a rim of apparent resorption origin, comparable with those so common about hornblende. This zone has a granular appearance and is usually not resolvable into distinct mineral constituents, but where the grain affected is in contact with the surrounding rock reddish-brown mica, magnetite, and a predominant pale green pyroxene seem to be the resulting minerals.

In the rock of Orenda Butte numerous pebble-like inclusions were found which belonged principally to two types, one consisting almost entirely of labradorite with a few specks of ferromagnesian minerals, and the other a granular mixture of quartz and alkali feldspar. In the former a cloudy alteration of the plagioclase penetrating between the grains and on cleavage planes is like that already described.

The quartz-alkali feldspar rock shows much greater alteration. Megascopically these inclusions are seen to be very irregularly porous, the feldspar dull and the quartz grains much cracked. Under the microscope the feldspar presents various intermediate stages of alteration from the normal mineral to a glass. The progress of alteration is marked by the appearance of a cloud of minute dark bodies along basal and pinacoidal cleavage planes and on chance fractures. These seem under high powers to be gas pores and to be connected by irregular arms where most numerous. The optical action of the feldspathic substance is often distinguishable but much weakened. A peculiarity observed in one of the inclusions seems worthy of notice. It is the development of the apparent gas pores on curving concentric planes comparable only to those of typical perlite. This phenomenon is most distinct and takes place in feldspar substance still showing optical action though weaker than normal. Isotropic arms representing complete fusion penetrate many grains following the cleavage and other fissures marked by the cloudy parts. The recrystallization of the melted parts has yielded a fine, irregular spherulitic growth in some places.

Art. XVII.—*Stylolites;* by T. C. Hopkins.

Stylolites, "Crow-feet" or "toe-nails" as they have been called by the quarrymen, form a very conspicuous feature in the oölitic limestone quarries in Indiana. As they seriously injure a great quantity of otherwise handsome building stone, they have a peculiar interest to the quarryman. The writer, in his recent investigations for an economic report on this limestone, was early impressed with the commercial importance and scientific interest of the stylolitic seams. An examination of the accessible literature on the subject failed to reveal a satisfactory explanation.* The only commonly accepted theory in the English literature is that given by Marsh and accepted by both Dana and Geikie in their text-books, i. e. that they are caused by the slipping through vertical pressure of a part capped by a fossil shell against an adjoining part not so capped.

However applicable this theory may be in other localities, it appears to be untenable in the Indiana oölitic limestone region because (1) a very small percentage, probably less than one per cent, of the stylolites are capped with fossils; (2) many of those that are capped with shells have a fragile gastropod shell that shows no evidence of distortion or pressure in any way; (3) in many places where the stylolites are a pronounced feature of the rock, there are shells in abundance a few inches or a few feet above and below the stylolites, but none at or near them; (4) in many places the stylolites show just the opposite to pressure, occurring along an open bedding seam.

Other theories which appear to be discarded now are shown in some of the old names, such as *lignilites*, from their resemblance to wood, possibly thought to be fossilized wood. Crystallites presupposes them to be caused by crystallization, and the term *Epsomites* that the crystals were Epsom salts. Other names by which they have been known are *suture joints* and the quarrymen's terms *crow-feet* and *toe-nails*. They frequently prefix a harsh adjective to these terms.

Before offering an explanation for their origin a brief description is here given, as they no doubt differ in some particulars from stylolites elsewhere. They occur along nearly horizontal seams and appear in the quarry face very much as a suture joint, running nearly horizontal. Projecting both down and up from the general direction of this seam are numerous tooth-like projections which vary in length from a fraction of an inch to five or six inches. The projections are sometimes

* The views of different German writers mentioned later were not known to the writer until after the formation of his own theory.

pointed and sometimes straight. The sides are generally roughly striated but not slickensided. The line of the seam is nearly always black or very dark-colored. There is frequently a thin layer of clayey material and rarely a little iron pyrites in the seam. The rock immediately adjoining the seam is frequently blue in color even when the surrounding rock is buff.

It is the opinion of the writer that the stylolite seams are bedding seams because (1) they correspond with the grain or bedding of the rock, occasionally running on the false bedding but never across the grain; (2) they are in places traceable with no break or sharp line of division into the common bedding planes having no evidence of stylolites; (3) there is in nearly every instance a layer of carbonaceous material, sometimes a mere film, sometimes nearly half an inch thick; (4) they are always of considerable though not unlimited extent; (5) a view from above, shown in a few places on quarry floors, shows water action not unlike the common bedding plane; (6) they frequently occur between the oölitic stone and the underlying Harrodsburg limestone or the overlying Mitchell limestone, beds which are not at all oölitic; (7) the cross bedding always terminates at the stylolite seam; in no instance was it observed to cross it.

The explanation of the stylolitic or tooth-like markings along this seam is not so satisfactory as is the evidence of its being a bedding seam. It is quite probable that they have been caused by different agencies. Some may be mud cracks, some may be due to the action of rain or spray on the exposed surface and some may be caused by the escape of gases from the limestone mud. Other agencies may have been active, but the first two mentioned above appear to the writer to be the more probable.

The following theories proposed by different German writers are many of them suggestive, but do not appear to have met with any favor by the English writers, if indeed they have been consulted. Plieninger* thought that the cracks or crevices originating at the surface by the drying mud were the cause, and that the pillar-like or columnar forms could be produced by rain.

Von Cotta and Rossmassler† put them in the same class with the "ice needles" produced on the surface of the soil in winter.

Fallati and Quenstedt have likened the stylolites to glacial pyramids of ice left on the surface of the glacier, or little pyramids of earth which owe their columnar structure to a

* Württemberg Naturwiss. Jahreshefte, 1858, vol. xiv, p. 292.
† Zirkel, Lehrbuch der Petrographie, 2d ed., vol. i, p. 535.

small stone or shell protecting the material underneath, while that surrounding is washed away by the rain in the case of the earth and by the sun on the ice.

Weiss,* corroborating the above, states that in his observations in a Bundsandstein formation, that a foreign body like a mussel shell or a piece of clay forms a protective covering to the drying lime particles, whereby the drizzling water has modeled out the stylolite by carrying away the material between the protected parts.

Zelger,† after detailed work on the stylolites, announces that they are formed by the escape of compressed gases through the soft plastic mass and the later filling of the passage-ways.

Gümbel states that the stylolites, particularly those from Rudersdorf, carry on top a clay cap which without doubt has come from a clay or marl layer which marks the lower limits of the bed of stone bearing the stylolites, and which is a part of the underclay layer ascending with the stylolite mass.

Zirkel‡ says that the stylolites remind one of the phenomenon called creeps by the English miners, in the swelling up and pressing in of the underclay of the coal into the galleries or openings made in the working until the gallery is filled by the underlying clay.

Quenstedt states§ that they are due to the filling in of hollow spaces made in the rock while yet soft by the movements of mussel shells. His later view was that where two beds overlie one another, separated by shells and a layer of clay or marl, the two beds having a different hardness, the pressure of the overlying mass would tear the clay bed and the underlying and overlying beds would be pressed into one another, thus causing the stylolites.

It will thus be seen that the German writers nearly all agree in thinking that the stylolites are bedding planes but do not agree in the origin of the tooth-like markings. As there is a difference in the appearance of the stylolitic points at different localities so they may be caused by different agencies. Some of them are evidently mud cracks caused either by the sun (Plieninger) or by the frost (Von Cotta). Some are apparently caused by the action of the rain or spray on the limestone mud (Fallati, Quenstedt, Weiss); but some may in part be caused by organisms of some sort (Quenstedt) or by the escape of gases (Zelger) from the plastic mud.

The cone-in-cone structure closely allied in some respects to the stylolites was not observed anywhere in the oolitic limestone district.

* N. Jahrb. f. Min., 1868, p. 729.

† Ibid., 1870, p. 833.

‡ Lehrbuch der Petrographie, vol. i, p. 536.

§ N. Jahrb. f. Min., 1837, p. 496, and Württemberg Naturwiss. Jahreshefte, 1853, ix, p. 71, and Epochen der Natur, 1860, p. 200.

ART. XVIII.—*On the Extinct Felidæ;* by GEO. I. ADAMS.

SINCE publishing my studies on the Extinct Felidæ of North America* I have had the opportunity of seeing many of the European and Indian specimens, and I now wish to publish some further corrections in the synonomy of the group and emphasize the distinctions which exist among certain genera. I am indebted to Dr. Gaudry of the *Jardin des Plantes* and to Dr. Woodward of the British Museum for privileges of study.

Structure of the Canines of the Felidæ.

The structure of the canines of the Machærodonts with their posterior and anterior denticulate borders is well known, but some errors have arisen from the failure to recognize that the same elements are present in the canines of all the Felidæ. An examination of the unworn canines of the lion, for example, will show that there are two roughened ridges on the interior face of the tooth which correspond to the denticulate lines found in *Machærodus*. In *Pseudælurus* the canines have a structure intermediate between those of *Felis* and *Machærodus*. They are described as being rounded anteriorly and having the posterior border sharp and denticulate. The anterior denticulate ridge is however present, but is situated on the inner face of the tooth except near the point where it forms the anterior border. The accompanying outlines and cross-sections will give an idea of the structure found in each.

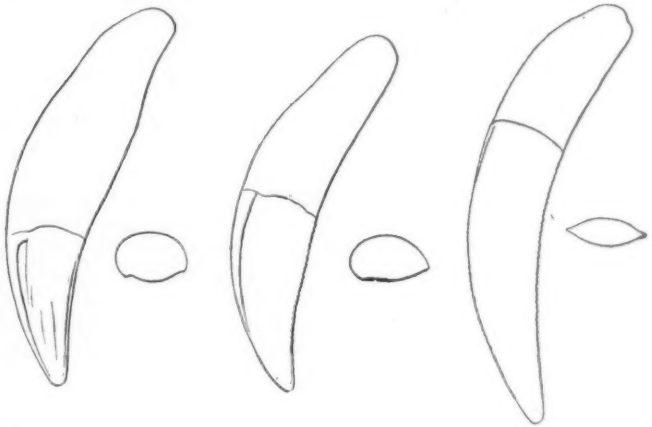


FIG. 1. *Felis leo* × ½. FIG. 2. *Pseudælurus* × ½. FIG. 3. *Machærodus* × ½.

* This Journal, June, 1896.

In all cases where the teeth are well preserved and unworn these roughened ridges or denticulate borders are present. The canines of *Ælurogale* are rounded anteriorly and have a sharp posterior border which is denticulate. The anterior denticulate line is located on the inner face as in *Pseudælurus*. The somewhat peculiar canines of *Nimravus* which are described as pike-shaped are after all not so anomalous. The posterior border, as was noted in the original description, is denticulate and the anterior face is rounded, a sharp ridge separating it from the inner. The canines of *Archælurus* are described as without anterior or posterior denticulate ridges, but as I have previously stated these are not well preserved. It is not probable however that they differed from all other known specimens of the Felidæ. While the canines of *Nimravus* are exceptionally straight they are not so peculiar as the illustration would suggest.

GENUS *Nimravus* Cope.

(Synonyms, *Archælurus* Cope, *Ælurogale* Filhol, *Ailurictis* Trouessart.)

The structure of the molar series in *Nimravus*, *Archælurus* and *Ælurogale* is the same, and now that the canines are shown to possess no essential differences I propose to combine them in one genus. *Ælurogale* has been shown by Trouessart* to be occupied, hence *Nimravus* would have the priority. The genus as thus constituted would be defined as follows:

Dentition $\text{Pm}\ \frac{4-3}{4-2}\ \text{M}\ \frac{1}{2-1}$. Superior canines rounded anteriorly, posterior border sharp and denticulate, the anterior denticulate ridge situated on the inner face of the tooth at its base but forming the anterior border near its point. Superior sectorial without anterior cusp, no positive inner cusp present, the inner root supporting instead a convex buttress which descends from the principal cusp. Lower sectorial with heel but no postero-internal cusp. Anterior portion of the mandible with an obtuse angle separating the anterior face from the inferior. The variation in dental formula is quite remarkable, but Filhol has already noted as great a variation for *Ælurogale*. The dentition of *Nimravus gomphodus* is $\text{Pm}\ \frac{3}{2}$ $\text{M}\ \frac{1}{2}$, but in a second specimen the small tubercular molar is absent from one side. The dentition of *Archælurus* is $\text{Pm}\ \frac{4}{3}$ $\text{M}\ \frac{1}{2}$, that of the type specimen of *Ælurogale*, $\text{Pm}\ \frac{3}{3}$ $\text{M}\ \frac{1}{2}$. The genus also shows a considerable variation in size and one com-

* Catalogue des carnivores vivants et fossiles 1886. "Le nom d'Ailurogale ayant été employé precedement par Fitzinger, pour un sous-genere des chats actueles (type *Felis planiceps*) nous avons proposé de changer le nom du present genre en *Ailurictis*."

parable with that of the *Hoplophoneus* and *Dinictis* series. The genus is represented in both North America and Europe and it is probable from a jaw fragment described by Lydekker as *Ælurogale sivalensis* that the geographical range extended to India.*

Genus *Machærodus.*

I wish to add some notes from my observations of the type skulls of *M. meganteron* and *M. palmideus*. *Machærodus* differs from *Hoplophoneus* in having basal cusps on the premolars and a small second anterior cusp on the superior sectorial. In regard to this last point I was in error in my previous definition of the genus. The cusp being very small I failed to recognize it in the illustrations, mistaking it for the cingulum. The alisphenoid canal is present just as in *Hoplophoneus* and the post-tympanic and post-glenoid processes are well separated. The close resemblance between the two genera in other respects than those of dentition makes it very probable that *Hoplophoneus* is the direct ancestor of *Machærodus*.

Genus *Smilodon* (Syn. *Dinobastis* Cope).

There is a tendency among European palæontologists to disregard this genus, including it in *Machærodus*. This is probably in part due to the fragmentary condition of European specimens which often makes certain characteristics indeterminate. The genus *Smilodon* differs from *Machærodus* as regards dental characters as follows. The second anterior cusp on the superior sectorial, which is incipient in *Machærodus*, is well developed in Smilodon, and the basal cusps on the premolars are much larger. The incisors have basal cusps, while in *Machærodus* there is only a suggestion of this element. There are perhaps no new structural elements nor have any been lost, but there are developmental differences. In the skull however there are decided structural differences, namely, the absence of the alisphenoid canal and the coössification of the post-glenoid and post-tympanic processes below the auditory meatus. The teeth being the parts most often preserved, these points are unfortunately indeterminate in some well known specimens, but that should not be an excuse for overlooking their value. Lydekker has figured the posterior portion of a skull of *M. sivalensis*† Falc. and Caut., showing the coössifi-

* Pal. Indica, Series X, vol. ii, p. 317.

† The indistinct figure of the superior sectorial of this species, so often repeated along with the statement that it possesses an internal cusp, has caused some confusion. Bose has previously stated that it has none. An examination of the specimen shows that there is an internal buttress as is commonly found in the genus, but no cusp.

cation of the post-glenoid and post-tympanic processes and has called attention to its resemblance to American Smilodons but did not refer it to that genus. *M. palæindicus* Bose will also probably prove to be a *Smilodon*.

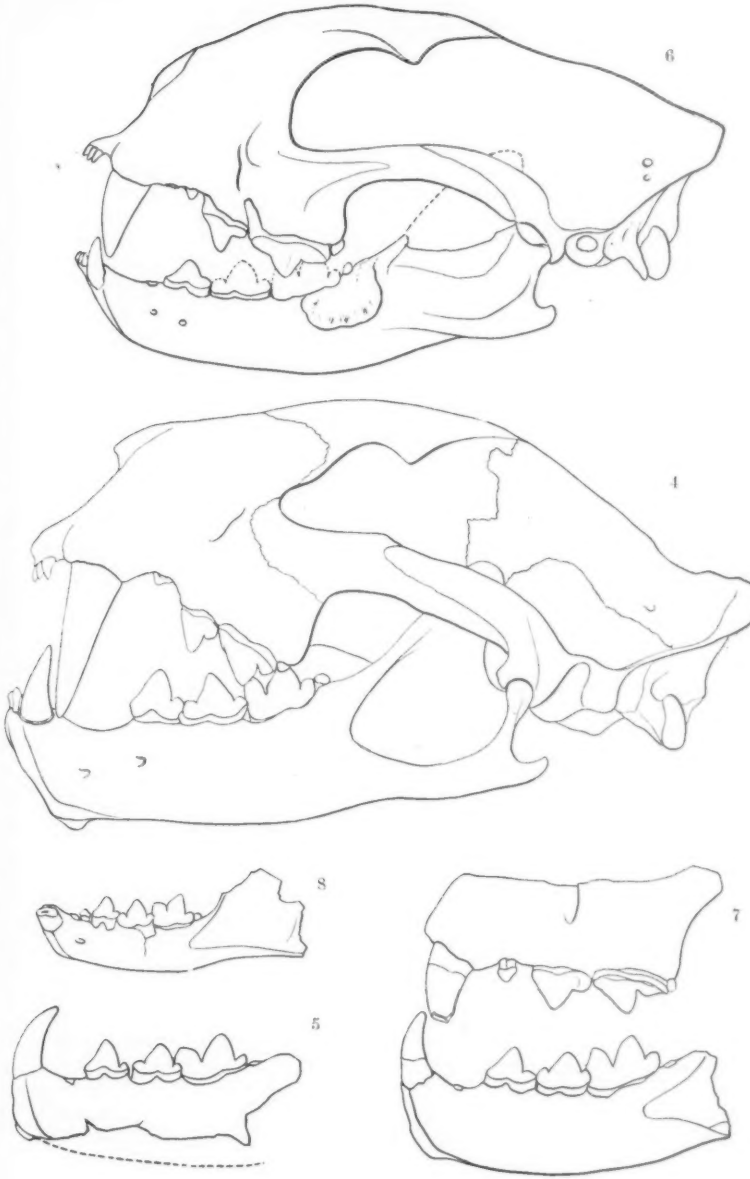
The specimen from Pikermi, in the Munich museum, described by Wagner as *F. leoninus* and now referred to *M. cultrideus*, is very like *Smilodon*, but only the anterior portion of the skull is preserved. *M. latidens* was described by Owen from a canine and an incisor having basal cusps. Gervais has since referred other material to this species. *Dinobastis* Cope, in which the generic character is the absence of the internal root of the superior sectorial, is known only from teeth and a few foot bones. The incisors, as Cope has noted, have basal cusps. There are strong resemblances between this specimen and the material now referred to *M. latidens*. There is some hesitancy in accepting a genus founded upon such limited material, especially when the differences are so slight. *Dinobastis* can very reasonably be considered a synonym of *Smilodon*. Finally the genus Smilodon is not only a later developmental form but is found in later deposits, and this is not an unimportant argument in favor of retaining it as a distinct genus.

EXPLANATION OF FIGURES 4 TO 8.

All figures $\times \frac{1}{2}$.

FIGURE 4.—*Nimravus gomphodus* Cope, after Cope.
FIGURE 5.—*Nimravus confertus* Cope, after Cope.
FIGURE 6.—*Nimravus debilis* (*Archælurus debilis* Cope), after Cope.
FIGURE 7.—*Nimravus intermedius* (*Ælurogale intermedius* Filhol), after Filhol.
FIGURE 8.—*Nimravus minor* (*Ælurogale intermedius*, var. *minor*, Filhol), after Filhol.

Lawrence, Kansas.



Nimravus series $\times \frac{1}{4}$.

SCIENTIFIC INTELLIGENCE

I. Chemistry and Physics.

1. *On the Electrical Convection of certain Dissolved Substances.*—In their investigations upon solution and pseudo-solution, Picton and Linder have studied the nature of the electric transmission which takes place by means of certain dissolved substances. In the case of arsenous sulphide, for example, the conductivity of its solution is extremely low, the current passing being in one case only $7 \cdot 10^{-6}$ ampere; and even this may be due to traces of the oxide. The passage of this small amount of current, however, is accompanied by the repulsion of the colloidal sulphide as a whole from the negative electrode. Using other substances, it appeared that in colloidal solutions which are too coarse-grained to pass through a porous pot and which show a coarse-grained structure by the optical test,* such as arsenous sulphide (γ), ferric hydrate and silicic acid, it is impossible to repel the dissolved substance vertically upwards as completely as downwards; a result due presumably to the action of gravity on the large colloidal particles. If, however, high grade solutions be employed, such as iodine, aniline blue and magdala red, which are readily filterable and which do not contain particles large enough to scatter light, then the substances can be repelled completely from the lower electrode, provided the solution is not too strong. In the case of aniline blue, however, the repulsion is complete even with 2 or 3 per cent solutions. If the solvent be highly non-conducting, as carbon disulphide for example, then no repulsion is observed. Thus while iodine in an imperfectly conducting medium was repelled from the negative electrode, an electromotive pressure even of 210 volts failed to show repulsion when the iodine was dissolved in carbon disulphide. The rapidity of the repulsive action seems to vary with the current strength; while its direction depends on the chemical character of the dissolved substance. Thus ferric hydrate, which is basic, is repelled from the positive electrode; while iodine and arsenous sulphide, which are acidic, are repelled from the negative electrode. In the case of the dyes mentioned, the result is not so simple; aniline blue, for example, being repelled from the negative electrode whether as disodium salt or as sulphonic acid. Hence hydrolysis seems to take place, which in this case would give in solution sodium hydroxide and sulphonic acid; so that the repulsion is due to the latter product. A table is given showing the results of an examination of a large number of substances in this way. On mixing acidic and basic dyes, the aggregates form lower grade solutions and are carried as a whole by the convection. By adding alcohol, however, dissociation appears to occur and the dyes are repelled in opposite directions. The authors

* See this Journal, III, xlix, 467, June, 1895.

call attention to this remarkable mimicry of ionic dissociation. Are these slowly moving molecules conveying two currents in a way at all analogous to conduction by ions? Curiously enough, in some of these separations a banded structure has been observed, recalling the phenomenon of stratification in gases.—*J. Chem. Soc.*, lxxi, 568–573, May, 1897. G. F. B.

2. *On the Phenomena of Supersaturation and Supercooling.*—The phenomena attending the solidification of supersaturated solutions and of supercooled liquids have been studied by OSTWALD. By suitably selecting the substances used, he has avoided the influence of dust particles; and he then finds that solidification is brought about only by the introduction either of a crystal of the same substance or of one strictly isomorphous with it. Thus fused salol, melting at 39·5°, cannot be made to crystallize at common temperatures by any of the ordinary means. But if a fine glass thread be drawn over a salol crystal, it will induce crystallization; though it loses this power by exposing it to the air for a few minutes, by wiping it with rubber, or by warming it to 40°. The author finds, however, that the temperature range below the melting point in which spontaneous production of crystals is impossible, is quite limited, the liquid being in stable equilibrium except towards a ready formed crystal. To this condition he gives the name *metastable*. At lower temperatures, no nuclei are necessary, the crystals forming spontaneously. Moreover it appears that there is an inferior limit to the quantity of substance required to start the crystallization, the two methods tried, successive dilution on the one hand or the evaporation of progressively more dilute solutions on a platinum wire on the other, giving identical results. In the case of sodium chlorate, a solution containing 107 parts of the salt in 100 of water can be made to crystallize by the introduction of a millionth or even a ten millionth of a milligram. That a minute fragment of ammonium alum causes a solution of potassium alum to crystallize, he explains by supposing the diffusion of the dissolved salt into the solid particle as soon as it comes in contact with the solution. The author concludes that when a system passes from any given condition to a more stable one, it will not pass into the state which under the circumstances is the most stable, but into that which is nearest to the original state.—*Zeitschr. f. physikal. Chemie*, xxii, 289, April, 1897. G. F. B.

3. *On a Thermochemical Method for determining the Equivalents of Acids and Bases.*—A thermochemical method has been proposed by BERTHELOT by means of which the equivalent of an acid or a base may be determined even when the compound is of unknown composition. For this purpose a given weight, p, of the acid is made up to a given volume, say two liters, with distilled water. A convenient quantity, say 500^{cc}, is taken, and 100^{cc} of potash solution (KOH = 2 liters) added, the heat produced, q_1, being measured. Then a second 100^{cc} are added and the heat, q_2, is measured; the process being continued n times until no more

heat is produced on the addition of alkali. The heat thus measured $(q_1 + q_2 + \ldots\ldots + q_n)$ which is the total heat of combination, is one quarter of that which the weight of the acid taken, p, would evolve. From the equation $E = 2000\,p\,/\,400\,n = 5\,p\,/\,n$ the equivalent of the acid E can be obtained, approximate to $1\,/\,n$th. Obviously the quantity of alkali added at first should not be sufficient to neutralize all the acid taken, since in that case p_2, p_3, etc. become zero. If the more accurate determination of the equivalent be desirable, a repetition of the experiment is made, using acid of the same strength but a potash solution only 1/10th as strong; the result in this case being approximate to $n\,/\,10$th. With monobasic acids the values of q_1, q_2, etc. are equal; with many polybasic acids they differ among themselves, decreasing with the successive additions of alkali. The equivalent of a base is fixed in a similar way, these rules applying only to soluble acids or bases yielding soluble salts.—*Ann. Chim. Phys.*, VII, vii, 283, February, 1897. G. F. B.

4. *On the Action of Potassium and Sodium vapor in coloring the Haloid salts of these metals.*—The blue color produced by the action of the cathode rays on crystals of sodium chloride, so similar to blue rock salt, has suggested to GIESEL the feasibility of coloring such crystals by purely chemical methods. In fact by heating the crystals with the vapor of sodium or potassium in a closed tube, color is readily developed, the particular color being independent of the metal employed. Thus treated, potassium bromide and iodide are colored deep blue; potassium chloride dark heliotrope and sodium chloride yellow to brown, the color appearing to permeate the whole crystal. It is permanent in the air, and also in water so long as the crystal is undissolved. The solution is colorless and gives a colorless residue. On heating, the color disappears. The yellowish brown sodium chloride however, when heated, becomes gradually yellow, red and bluish violet and finally colorless; but by cooling at any particular stage the color then possessed becomes permanent. So that a shade of blue may be thus obtained identical with that of the natural rock salt.—*Ber. Berl. Chem. Ges.*, XXX, 156, February, 1897. Kreutz claims to have obtained this result in 1892.—Ib. p. 403. G. F. B.

5. *On the Action of the Silent Electric Discharge on Helium.*—The conditions under which helium will enter into combination have been studied by BERTHELOT. The method used as well as the apparatus were the same as those employed in the case of argon, the graduated tubes permitting the measurement of 5^{cc} of gas to 1/200 and even to 1/500 of a cubic centimeter. Comparative experiments were made with nitrogen, argon and helium. Placed in a closed tube over mercury and submitted to the electric discharge for 12 to 15 hours, neither of these gases either combined with the mercury, suffered any molecular condensation or developed fluorescence. In presence of benzene vapor, however, nitrogen developed fluorescence and disappeared in a few hours. Argon

was slowly absorbed, reaching a limit of 15 per cent absorbed in 10 or 12 hours; a brilliant greenish fluorescence being produced, whose spectrum showed the lines of argon, hydrocarbon and mercury. Helium under these conditions showed a characteristic fluorescence of an orange color at the end of 11 hours, the absorbed gas being about 8 per cent. In its spectrum were seen the lines of helium, mercury and hydrocarbons. After 17 hours, 13·7 per cent of the helium was absorbed and after 39 hours 16 per cent, yielding a solid polymerized volatile resin, as do argon and nitrogen. When bisulphide of carbon was used in place of benzene, nitrogen was rapidly absorbed, argon and helium more slowly, with a faint luminosity. After 175 hours 54 per cent of argon was absorbed, and after 192 hours 55·5 per cent of helium; this latter being increased to 68·4 per cent after 210 hours. The result is a carbonaceous mass mixed with sulphur and combined with the absorbed gas, recalling the sulphocyanides. On heating this substance in a vacuum to a red heat, a considerable volume of gas was obtained, which after removal of the regenerated carbon disulphide and a trace of carbon monoxide, gave, when subjected to the action of the electric discharge in presence of benzene, the characteristic reactions of helium. The residual unabsorbed gas behaved similarly. From the identical behavior of the initial gas, of the gas absorbed by carbon disulphide and then regenerated and of the residual gas, the inference is strong in favor of the homogeneity of helium.—*C. R.*, cxxiv, 113, January, 1897. G. F. B.

6. *Further Note on the Influence of a Magnetic Field on Radiation Frequency;* by OLIVER LODGE, assisted by BENJAMIN DAVIES. Read June 3, 1897, before the Royal Society.*

Referring to a former communication of mine, on the subject of Zeeman's discovery, printed on page 513 of the "Proceedings of the Royal Society" for February 11 this year, vol. lx, No. 367, I wish to add an observation to those previously recorded, as I have recently acquired a concave Rowland grating ($3\frac{1}{2} \times 1\frac{1}{2}$ inch ruled surface, 14,438 lines to inch, 10 feet radius of curvature, being the one used by Mr. George Higgs), of which the spectra of the first and third orders on one side are very satisfactory.

It is said on page 513, "If the focussing is sharp enough to show a narrow, dark reversal line down the middle of each sodium line, that dark line completely disappears when the magnet is excited." With the greater optical power now available, the dark reversal line is often by no means narrow, and though in some positions of the flame it does still tend to disappear or become less manifest when the flame is subjected to a concentrated magnetic field, the reason of its partial disappearance is that it is partially reversed again—*i. e.*, that a third bright line, as it were, makes its appearance in the midst of the dark line, giving a triple appearance to each sodium line.

More completely stated, the phenomena are as follows: After

* From an advance proof sent by the author.

obtaining each sodium line with a prominently double aspect by manipulating the flame, the magnet is excited, and the dark band in the midst of each sodium line is then seen to widen out considerably in the region of most intense magnetisation, while a bright intrusion line makes its appearance. On closer examination this new line is seen to be double, by reason of a dark division down its middle; and I apprehend that with still more magnetic power this dark band might itself open out into two; but this last phenomenon I have not yet observed.

The whole sodium group is thus seen as if it were octuple. The effect is not due to a mere mechanical disturbance or rearrangement of the gases of the flame by the agency of magnetism; because a nicol, placed in the rays emanating transversely to the magnetic lines of force, cuts off nearly all the visible magnetic effect when oriented so as to get rid of light whose plane of polarisation contains the lines of force—that is, of oscillations or revolutions whose electrical components are across or around the magnetic lines. That it does not cut off every trace of the effect appears to be due to the fact that the field of force is not strictly uniform, and so its lines are not strictly parallel.

The following is a summary of the different appearances that may be seen according to the state of the flame and the strength of the field:—

At low temperature, and with the flame forward in the field, when each sodium line is sharp and single, magnetism widens it, and with a little more power doubles it, causing a distinct dark line down its middle. The same effect occurs with lithium and thallium lines.

At higher temperature, and with the flame partially behind the field, when each sodium line appears as a broad hazy-edged double, magnetisation greatly widens the doubling, pushing asunder the bright components very markedly: stronger magnetisation reverses the middle of the widened dark band, giving a triple appearance; stronger magnetisation still reverses the middle once more, giving a quadruple appearance to the line. In every case a nicol, suitably placed, cuts off all the magnetic effect and restores the original appearance of the line.

A curious circumstance is that although both lines D_1 and D_2 show the same effect, D_1, *i. e.*, the less refrangible line, shows it best and most sharply. I should describe the effect on D_2 as a coarse widening of considerable amount, but without very clear definition; whereas the widening of D_1, though perhaps no greater in amount, is decidedly better defined. There is no doubt but that, with my grating, D_1 is the line at which one finds oneself usually looking in order to see the details of the change best; and I can hardly suppose this to be subjective to the grating. I hope to show the effects at the soiree next Wednesday.

[The same thing is seen when salts of lithium or of thallium are introduced into the flame, and the components of the doubled

red lines are more widely separated than the components of the doubled green lines, the effect being proportional to wave-length. The most interesting line to try was the red cadmium line, since this has been proved to be of specially simple constitution by Michelson. We have recently been able to get the cadmium spectrum well developed by means of a sort of spark arc between the magnet poles, maintained by an induction coil excited by an alternating machine; and we find that the magnetic doubling of the chief lines occurs in precisely the same way with the spark spectrum as with the flame spectrum, and that the red cadmium line behaves in the same way as the others. The magnetic effect is better seen, from a direction perpendicular to the line of force, when a nicol is interposed in the path of the light, but rotation of the nicol through 90° cuts it entirely off, accurately so when a small spark is the source of light.—May 31.]

II. Geology and Mineralogy.

1. *Recent publications of the U. S. Geological Survey.**—The Seventeenth Annual Report for 1895–96 has three parts, all issued. Besides the paper already noted, Part I contains the following: *Magnetic Declination in the United States*, by Henry Gannett, pages 237, with map showing distribution of the magnetic declination in the United States in 1900. *Further Contributions to the Geology of the Sierra Nevada*, by H. W. Turner, pages 241, plates 30. Although much of this paper treats of structural geology, the larger part is petrographical. *Report on the Coal and Lignite of Alaska*, by W. H. Dall, pages 143, plates 11, with an appendix on the fossil plants by F. H. Knowlton. Another on the Paleozoic fossils by Charles Schuchert, and a third on the Mesozoic fossils by Prof. A. Hyatt. G. F. Becker and Dr. Dall were together on the Alaskan trip and Becker's report on the gold of that country will appear in the Eighteenth Annual. *The Glacial Brick Clays of Rhode Island and Southern Massachusetts*, by N. S. Shaler, J. B. Woodworth, and C. F. Marbut, pages 51, plates 2. This paper supports the view that the glacial period was divided into three great epochs of ice action separated from one another by very long intervals. *The Faunal Relations of the Eocene and Upper Cretaceous on the Pacific Coast*, by T. W. Stanton, pages 56, plates 5. Notwithstanding their conformability, Mr. Stanton recognizes a marked paleontological break between the Upper Cretaceous and the Eocene of California and Oregon.

Part II of the Seventeenth Annual, Economic Geology and Hydrography, contains the following papers:—*The Gold Quartz Veins of Nevada City and Grass Valley, California*, by W. Lindgren, pages 249, plates 24. This paper, although chiefly economic, contains much petrography. A folio of the region has

* Issued since January, 1897. See list in this Journal for February, 1897, page 153.

been published by the same author. *Geology of Silver Cliff and the Rosita Hills, Colorado*, by Whitman Cross, pages 160, plates 11, and *The Mines of Custer County, Colorado*, by S. F. Emmons, pages 67, plate 1, refer to the same region. The observations for these papers were made chiefly in 1883. The rapid decline of the district as a mining camp has greatly increased the difficulty of obtaining satisfactory data. *Geologic Section Along the New and Kanawha Rivers in West Virginia*, by M. R. Campbell and W. C. Mendenhall, pages 38, plates 12. *The Tennessee Phosphates*, by C. W. Hayes, pages 38, plates 6. There are three papers on hydrography. Those by Gilbert and Leverett have already been mentioned.* The final paper is a *Preliminary Report of the Artesian Waters of a Portion of the Dakotas*, by N. H. Darton, pages 93, plates 39.

The following monographs have been issued:—Monograph XXVIII, *Geology of the Denver Basin in Colorado*, by S. F. Emmons, Whitman Cross, and G. H. Eldridge, pages 556, plates 33, four of which are maps on a scale $\frac{1}{126,000}$, showing the topography, areal, economic and structural geology. The geology, excepting that of the Denver formation, is chiefly by Emmons and Eldridge. The Denver formation and the petrography are by Mr. Cross.

Chapter VII on Paleontology was contributed by Mr. F. H. Knowlton and Prof. O. C. Marsh.

Monograph XXVIII, *The Marquette Iron-bearing District of Michigan*, by C. R. Van Hise and W. S. Bayley, with a Chapter on the Republican Trough by H. L. Smyth, pages 608, plates 36, and atlas of 39 maps. The geology is chiefly by Van Hise and the petrography by Bayley. The volume is most handsomely illustrated.

The following bulletins have been issued:—

No. 137, *The Geology of the Fort Riley Military Reservation and Vicinity, Kansas*, by Robert Hay, has 35 pages.

No. 139, *Geology of the Castle Mountain Mining District, Montana*, by W. H. Weed and L. V. Pirsson, contains 164 pages. A geological map, based on the topography as outlined by the Transcontinental survey, shows the distribution of a large number of rocks from the Algonkian to the Miocene inclusive with a full series of acid and basic eruptives.

No. 141, *The Eocene Deposits of the Middle Atlantic Slope in Delaware, Maryland and Virginia*, by W. B. Clark, has 166 pages, and 40 plates. The geological and paleontological data, including a considerable number of new species, are fully illustrated and discussed, and Prof. Clark is decidedly of the opinion that the Eocene deposits of the Middle Atlantic slope represent the greater portion of the Eocene series of the Gulf, its upper members alone excepted.

No. 143, *Bibliography of Clays and the Ceramic Arts*, by J. C. Branner, has 114 pages.

* This Journal, February, 1897, p. 154.

No. 144, *The Moraines of the Missouri Coteau and their Attendant Deposits*, by J. E. Todd, has 71 pages and 21 plates. The paper includes a map of the glacial phenomena in parts of North and South Dakotas, and numerous illustrations of the three moraines and other various attendant deposits in that portion of the great terminal moraine belt.

The following folios have been issued:—

No. 28, *Piedmont, Maryland and West Virginia*, latitude 39° to 39° 30′, longitude 79° to 79° 30′, by N. H. Darton and J. A. Taff.

No. 30, *Yellowstone National Park, Wyoming*, embracing four sheets, Gallatin, Canyon, Shoshone and Lake, on the scale of $\frac{1}{125,000}$, by Arnold Hague, J. P. Iddings and W. H. Weed.

No. 32, *Franklin, Virginia and West Virginia*, latitude 38° 30′ to 39°, longitude 79° to 79° 30′, by N. H. Darton.

The Geological Survey has already issued 166 topographic sheets, of which 27 have been issued since February 1st. By Act of Congress, these have recently been placed on sale at 5 cents apiece, or $2.00 a hundred copies. J. S. D.

2. *The Pleistocene Features and Deposits of the Chicago Area;* by Frank Leverett, U. S. Geol. Survey. (Bull. No. II, Geol. and Nat. Hist. Survey of the Chicago Acad. Sciences), pp. 1–87, May, 1897.—Mr. Leverett's minute knowledge of the surface features of Illinois and neighboring States gives special value to this detailed analysis of the Pleistocene deposits in relation to ancient glacial phenomena.

In his classification of the drift sheets, as marks of chronology, he follows and amplifies the outline of Prof. Chamberlin, already published. He recognizes fifteen stages and substages in the glacial history of the region, as follows:—

"Outline of the drift sheets and intervals.

1. Oldest recognized drift sheet—the Albertan of Dawson.
2. First, or Aftonian, interval of recession or deglaciation.
3. Kansan drift sheet of the Iowa geologists.
4. Second interval of recession or deglaciation.
5. Illinoian drift sheet.
6. Third, or preloessial, interval of recession or deglaciation.
7. Iowan drift sheet and main loess deposit.
8. Fourth, or post-loessial, interval of recession or deglaciation.
9. Early Wisconsin drift sheets.
   - Substage 1. Shelbyville morainic system.
   - Substage 2. Champaign morainic system.
   - Substage 3. Bloomington morainic system.
   - Substage 4. Marseilles morainic system.
10. Fifth interval of recession, shown by shifting of ice lobes.
11. Late Wisconsin drift sheets.
    - Substage 1. Great bowlder belts and accompanying moraines.
    - Substage 2. Valparaiso morainic system.
    - Substage 3. Lake-border morainic system.

12. Lake Chicago submergence.
13. Emergence of plain, covered by Lake Chicago.
14. Partial resubmergence of plain, covered by Lake Chicago.
15. The present stage of Lake Michigan." H. S. W.

3. *A new fossil Pseudoscorpion.*—Prof. HANS BRUNO GEINITZ of Dresden has sent out a preliminary notice of a unique fossil pseudoscorpion, named by him *Kreischeria wiedei* Gein. It was recently discovered in the lower layers of the Sigillaria zone in the "Morgenstern" mine, at Reinsdorf near Zwickau. A full description is promised in the next number of the *Zeitschrift der deutschen geologischen Gesellschaft.* The length of the body, without jaws, feelers or legs, is 50 millimeters, and it is about 28^{mm} wide at its most expanded part. The specimen will be deposited in the K. Mineralogisch. Museum in Dresden.

H. S. W.

4. *Catalogus Mammalium tam viventium quam fossilium;* a Dr. E.-L. TROUESSART, Nova Editio (prima completa), Berlin, 1897 (R. Friedländer & Sohn).—Fasciculus II of this work, pp. 217–452, has recently been issued. It contains the Carnivora, Pinnipedia, Rodentia I. Protrogomorpha et Sciuromorpha.

H. S. W.

5. *Brief Notices of some recently described Minerals.*—LEONITE. A new sulphate described by Tenne from the salt deposits of Leopoldshall; it corresponds to bloedite but contains potassium instead of sodium. It crystallizes in thick tabular crystals belonging to the monoclinic system; color pale yellowish, reddish or gray. Analysis led to the formula $MgSO_4 . K_2SO_4 + 4$ aq. Named after Director Leo Strippelmann.—*Zs. deutsch. geol. Gesellschaft*, xlviii, 632, 1896.

QUIROGITE. A sulphide of lead and antimony described by F. Navarro from the San Andres mines, Georgina, Sierra Almagrera, Province of Palmeria, Spain. It resembles galena but crystallizes in the tetragonal system, with a hardness of 3 and a specific gravity of 7·23; color gray on the surface but luster metallic on freshly fractured surfaces. An analysis gave:

S 17·51, Sb 9·69, Pb 63·89, Fe 6·30.

If the iron sulphide is to be regarded as foreign, the mineral consists of PbS and Sb_2S_3 in the ratio of 23:2.—*Anal. Soc. Espan.*, xxiv, 1896, in *Bull. Soc. Min.*, xx, 163, 1897.

DICKSBERGITE. A name given by Igelström to a supposed new mineral occurring with cyanite at Dicksberg in the Ransät parish, Wermland, Sweden. It has since been shown by Weibull and Upmark to be rutile.—*Geol. För. Förh.*, xviii, 231, 523, 1896.

MALTESITE. A variety of andalusite resembling chiastolite from eastern Finland, described by Sederholm. It occurs in mica schist in crystals of remarkable size, varying from 1·5 to 5 centimeters across.—*Geol. För. Förh.*, xix.

MANGANDALUSITE. Bäckström has given this name to a variety of andalusite occurring in the muscovite-quartzite of the Vestanå

region in Sweden. It is characterized by containing 6·9 p. c. of Mn_2O_3. In its pleochroism it differs from ordinary andalusite.

FUGGERITE. A mineral closely related to gehlenite, described by E. Weinschenk. It occurs as a contact mineral in the Monzoni region of the Fassathal. It crystallizes in tetragonal prisms with perfect basal cleavage; color white and greenish; specific gravity 3·18. An analysis by Mayr gave:

SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Ma_2O	
34·04	17·97	3·49	4·89	37·65	2·04	K_2O,MnO *tr.*=100·20.

Named after Prof. E. Fugger of Salzburg.—*Zeitschr. Kryst.* xxvi, 577, 1896.

MUNKFORSSITE. A mineral of uncertain character from the Ransät parish, Wermland, Sweden, imperfectly described by Igelström. It occurs with cyanite in white bladed forms; hardness=5. Analysis shows the presence of SO_3, P_2O_5, Al_2O_3, CaO, but little confidence can be placed in the numbers given. A relation to svanbergite is suggested.—*Zeitschr. Kryst.*, xxvi, 601, 1896.

BISMUTOSMALTITE. A variety of skutterudite from Zschorlau near Schneeberg, peculiar in its large percentage of bismuth. Described by Frenzel in *Min. petr. Mitth.*, xvi, 525, 1896.

6. *The Bendegó Meteorite.*—Dr. O. A. DERBY has recently published (Archivos do Museu Nacional do Rio de Janeiro, vol. ix) the results of a highly interesting and exhaustive study of the remarkable meteoric iron of Bendegó, in the province of Bahia, Brazil. The accounts of the early history of this wonderful mass are most interesting. It was discovered in 1784 and a year later a rude truck was built with the idea of removing it. This work proved to be of great difficulty, and after the mass had been dragged about 100 yards along the bed of the rivulet called the Bendegó, it was finally abandoned. It was visited again in 1811 by Mr. Mornay in company with Signor Botelho, the discoverer, who made measurements of its size, from which its cubic contents were estimated to be 28 cubic feet and its weight 14,000 pounds. It was again visited by Spix and Martius in March, 1818, who estimated the volume at 31 to 32 cubic feet, and the weight at 17,300 pounds. They removed some fragments, the largest of which was deposited in the Munich museum. Many years later, the extension of the railway brought up again the question of its removal, and finally in 1888 it was deposited in Rio Janeiro. The work of removal involved great care and called for much engineering skill.

Of the original fall of this great mass nothing is known, but the author concludes that it certainly antedated by a long period the time of its discovery. Some interesting local traditions in this connection are recorded. The weight of the mass, after the removal by cutting of a piece of 62 kilos, is stated to be 5,300 kilos (11,660 pounds); this is somewhat less than first estimated, but still gives it the first place among the meteorites of the great

museums of the world. The author describes with all necessary fullness the external appearance of the mass, certain portions of the surface of which seem to correspond in direction to the internal crystalline structure. The Widmanstätten figures are finely developed by etching; and numerous nodules of troilite were observed. These last have left by weathering a number of hemispherical and cylindrical cavities, which are a characteristic feature of the iron.

In connection with Dr. Hussak and Dr. Guilherme Florence, a minute study, leading to many interesting results, has been made of the different forms of nickel, iron and associated minerals present, namely: Kamacite and tænite; also cohenite, rhabdite; and further troilite, schreibersite, chromite and hypersthene. In addition to these species identified, a peculiar feature are small black spherical globules obtained from the rhabdite, which range from 0·1 to 0·2^{mm} in length and from 0·004 to 0·005^{mm} in thickness. Some of these are hollow spheres and others are developed in successive layers, like an onion. They have a fused appearance, and it is suggested that they may have resulted from the fusion of the phosphides, which are evidently the first mineralogical element to be individualized in the metallic magma. These metallic globules sometimes show cubic or octahedral crystalline faces.

The presence of fine etched lines, resembling file markings, is noted in the kamacite, especially in the vicinity of the troilite nodules. Also associated with these are raised lines, similarly arranged; these are called Bendegó lines. They consist of exceedingly delicate, perfectly regular plates of brilliant white metal resembling taenite, that stands out in relief on the etched surface. The various observed direction of these lines are explained as due to twinning, and Dr. Hussak finds evidence of polysynthetic twinning lamellæ parallel to the faces of the hexoctahedron (421).

III. Miscellaneous Scientific Intelligence.

1. *American Association for the Advancement of Science.*—The forty-sixth meeting of the American Association will be held at Detroit, Michigan, from August 9th to 14th. Dr. Wolcott Gibbs of Newport is the President-elect. The scientific sessions are to be in the Central High School and the hotel headquarters at "The Cardillac." The local Secretary, who has charge of transportation, hotel accommodations, etc., is Mr. John A. Russell, 401 Chamber of Commerce, Detroit. The Permanent Secretary is Prof. F. W. Putnam of Salem, Mass.

The interest of the coming meeting will be largely increased by the fact that the British Association is to meet this summer at Toronto, and it is expected that the members of the A. A. A. S. will go in a body to Toronto to join in welcoming the members of the B. A. A. S. to America.

2. *The Development of the Frog's Egg, an Introduction to Experimental Embryology;* by THOMAS HUNT MORGAN, pp. 192. New York, 1897 (The Macmillan Company).—Although the frog's egg has long been a favorite subject of investigation in both normal and experimental embryology, this book by Prof. Morgan is the first to give a summary of the experimental work of many investigators. Marshall, in his *Vertebrate Embryology*, has given a good and fairly well illustrated account of the normal development, particularly of the later stages, but in the work here noticed we have, especially for the earlier stages, a full account of the normal development followed by the results of numerous experiments by various investigators, including those of the author himself. Prof. Morgan's book gives us a much needed text-book for both student and instructor, and it should stimulate and greatly aid investigation by pointing out the wide field the frog's egg still offers for embryological research.

S. I. S.

OBITUARY.

ALFRED MARSHALL MAYER, Professor of Physics in the Stevens Institute of Technology, Hoboken, N. J., died on the 13th of July, in the sixty-first year of his age. He had been in failing health for some months, but had continued to discharge the duties of his professorship until February, and later increasing weakness and exhaustion caused his retirement to his country residence, Maplewood, South Orange, N. J., where his life came to a close in consequence of an attack of an apoplectic nature, from which he did not rally.

Professor Mayer was born in Baltimore, Md., Nov. 13, 1836, and received his education at St. Mary's College, Baltimore. After leaving this institution, in 1852, he spent two years in the office and workshop of a mechanical engineer, where he acquired a knowledge of mechanical processes and the use of tools, for which he had a natural aptitude. His experience here was of great service to him in his subsequent career. This was followed by a course of two years in a chemical laboratory, where he obtained a thorough knowledge of analytical chemistry. In 1856 he was made Professor of Physics and Chemistry in the University of Maryland, and three years later he entered upon a similar position in Westminster College, Mo., where he remained two years. In 1863 he went abroad, and entered the University of Paris, where he spent two years in the study of physics, mathematics and physiology. While in Paris he was a pupil of the distinguished physicist Regnault. After his return to this country he occupied a chair in Pennsylvania College, Gettysburg, and later in Lehigh University, Bethlehem, where he was in charge of the department of astronomy, and superintended the erection of an observatory. In 1869, an expedition was sent by the U. S. Nautical Almanac office to Burlington, Iowa, to observe the

eclipse of Aug. 7. Professor Mayer was placed in charge of the expedition, and made a large number of successful photographs. In 1871, he was called to the professorship of Physics in the Stevens Institute of Technology, which position he held until the close of his life.

Professor Mayer was an enthusiastic and active investigator, and a prolific writer upon scientific subjects. He had the command of a clear and graceful style, and possessed in a remarkable degree the power of presenting scientific subjects in a perspicuous and interesting manner. He made numerous contributions to various journals, cyclopædias, and other scientific publications, but the memoirs in which he embodied the results of his own researches were chiefly published in the American Journal of Science. His papers published in this Journal, since 1870, number forty-seven titles, covering nearly four hundred closely printed pages, not counting various notes and minor contributions. While embracing a great variety of topics in physics, his studies were more actively pursued in the departments of electricity and electro-magnetic phenomena, in optics, especially photometry and color-contrasts, but more particularly in acoustics, which was a favorite field of research, in which his discoveries gave him the prominence and authority of a specialist. His acoustical researches form a connected series of papers, in ten numbers, amounting to nearly one half the total volume of his contributions. The following somewhat abbreviated titles will indicate their purport:—The translation of a vibrating body causes it to give a wave-length differing from that produced by the same vibrating body when stationary (1872): a method of detecting the phases of vibration in the air surrounding a sounding body; and thereby measuring directly in the vibrating air the length of its waves and exploring the form of its wave-surface, resulting in the invention of the topophone (1872): a simple and precise method of measuring the wave-lengths and velocities of sound in gases; and on an application of the method in the invention of an acoustical pyrometer (1872): the experimental determination of the relative intensities of sounds; the measurement of the powers of various substances to reflect and to transmit sonorous vibrations (1873): experimental confirmation of Fourier's theorem; experimental illustration of Helmholtz's theory of audition; experiments on the supposed auditory apparatus of the mosquito, in which it is shown that the fibrils of the antennæ of the male mosquito vibrate sympathetically to sounds having the range of pitch of sounds emitted by the female mosquito; suggestions as to the function of the spiral scale of the Cochlea; six experimental methods of sonorous analysis; curve of musical note formed from six sinusoids of the first six harmonics; curves for various consonant intervals; experiments in which motions of a molecule of air are derived from these for six elementary vibrations of a musical note (1874): determination of the law connecting pitch of sound with the duration of residual

sensation; determination of the numbers of beats throughout the musical scale which produce the greatest dissonances; application of these laws by means of rotating perforated disks, and quantitative application of them to musical harmony (1874): experiments on the reflection of sound from heated flames and heated gases (1874): obliteration of one sound by simultaneous action of a more intense and lower sound; discovery that a sound even intense cannot obliterate sensation of a sound of lower pitch (1876): acoustic repulsion (1878): determination of the smallest consonant intervals among simple tones, and application to deduce the duration of residual sonorous sensations (1894): variation in the modulus of elasticity with change of temperature determined by transverse vibrations of bars at various temperatures; the acoustical properties of aluminium, showing that the metal is unsuited for musical instruments on account of the rapid and large changes in its elasticity by change of temperature (1896). In an elaborate paper published in the third volume of the Memoirs of the National Academy of Sciences, 1884, he gave a method of precisely measuring the vibratory periods of tuning-forks and determining the laws of their vibration, with their applications in chronoscopes for measuring the velocity of projectiles.

Among other papers published by Professor Mayer in this Journal may be mentioned: Researches in electro-magnetism, showing the changes in dimensions of iron and steel bars by magnetization; method of measuring electrical conductivity by means of two equal and opposed electrical currents (1870, 1873): on the electro-tonic state; on a method of fixing magnetic spectra (1871): new form of lantern galvanometer; mode of tracing the boundary of a wave of conducted heat (1872): on the composite nature of the electric discharge (1874): method of delineating the isothermal lines of the solar disk (1875): experiments with floating magnets (1878): the well-spherometer (1886): the pendulum electrometer; electric potential as measured by work; the spring balance electrometer; experimental proof of Ohm's law; cubical expansion of solids, by vessels or hydrometers made of the material of these solids (1890): illuminating power of flat petroleum flames; physical properties of hard rubber (1891): simultaneous contrast-color; photometer for lights of different color (1893): researches on the Röntgen rays (1896); equilibrium of forces acting in the flotation of disks and rings of metal, with determinations of surface tension (1897).

He also published "Lecture Notes on Physics" (Philadelphia, 1868); "The Earth a Great Magnet" (New Haven, 1872); "Light" (New York, 1877); "Sound" (New York, 1878); "Sport with Gun and Rod in American Woods and Waters" (1883).

Professor Mayer received the degree of Ph.D. from the Pennsylvania College in 1866. During the year 1873 he was one of the associate editors of this Journal. In 1872 he was elected a

member of the National Academy of Sciences, and was connected with many other scientific societies, among which may be mentioned the American Philosophical Society, the American Academy of Arts and Sciences, the New York Academy of Sciences, the American Metrological Society. He was also a corresponding member of the British Association for the Advancement of Science, and a Fellow of the American Association of the same name.

Professor Mayer's scientific work was marked by strongly characteristic traits. He possessed great ingenuity and skill in construction, and a remarkable degree of delicacy and precision as an experimenter, which enabled him to obtain results that will have a high and permanent value in science. Beyond his scientific accomplishments he was a man of wide and refined culture, with a genial presence, and social qualities which made him a delightful companion and endeared him to his friends. He leaves a wife and one son. A. W. W.

Professor A. Des Cloizeaux, the eminent French Mineralogist, died at Paris on the 6th of May, at the age of seventy-nine years. His contributions to Mineralogy, especially on the crystallographic and optical side, were very numerous and all of the highest character. The development of the methods for the study of the optical characters of crystals is largely due to him, and his three classical memoirs devoted to this subject and giving the results of the optical examination of a very large number of minerals and artificial salts, will always hold the first place in the literature; they were published in 1857, 1858 and 1864. The *Manuel de Minéralogie* is also a profound work containing the results of his own original observations. The first volume of 572 pages, devoted to the Silicates, was published in 1862; two portions of the second volume were issued much later, namely in 1874 and 1894 respectively. Professor Des Cloizeaux was a man of noble character and of charming personality; he was honored not only by those who had the privilege of his acquaintance but by the much larger number who knew him only through his scientific work.

Julius Sachs, Professor of Botany at Würzburg, died on May 29, in his sixty-fifth year.

Notice.—The Director of the Imperial Museum of Natural History has the honour of notifying that Mr. *Aristides Brezina* has ceased to be the chief of the mineralogical and petrographical section and that all letters, specimens and other consignments, especially those concerning meteorites, are to be addressed in future to the mineralogical and petrographical section of the Museum or to the chief of the same, at present Professor *Fritz Berwerth*, Vienna I Burgring 7.

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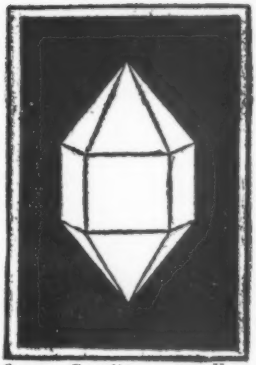

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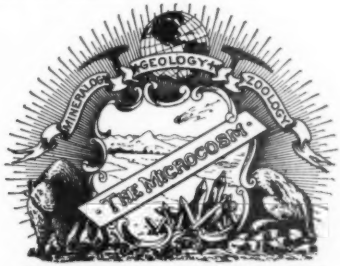

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(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci., Vol. 1. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894.

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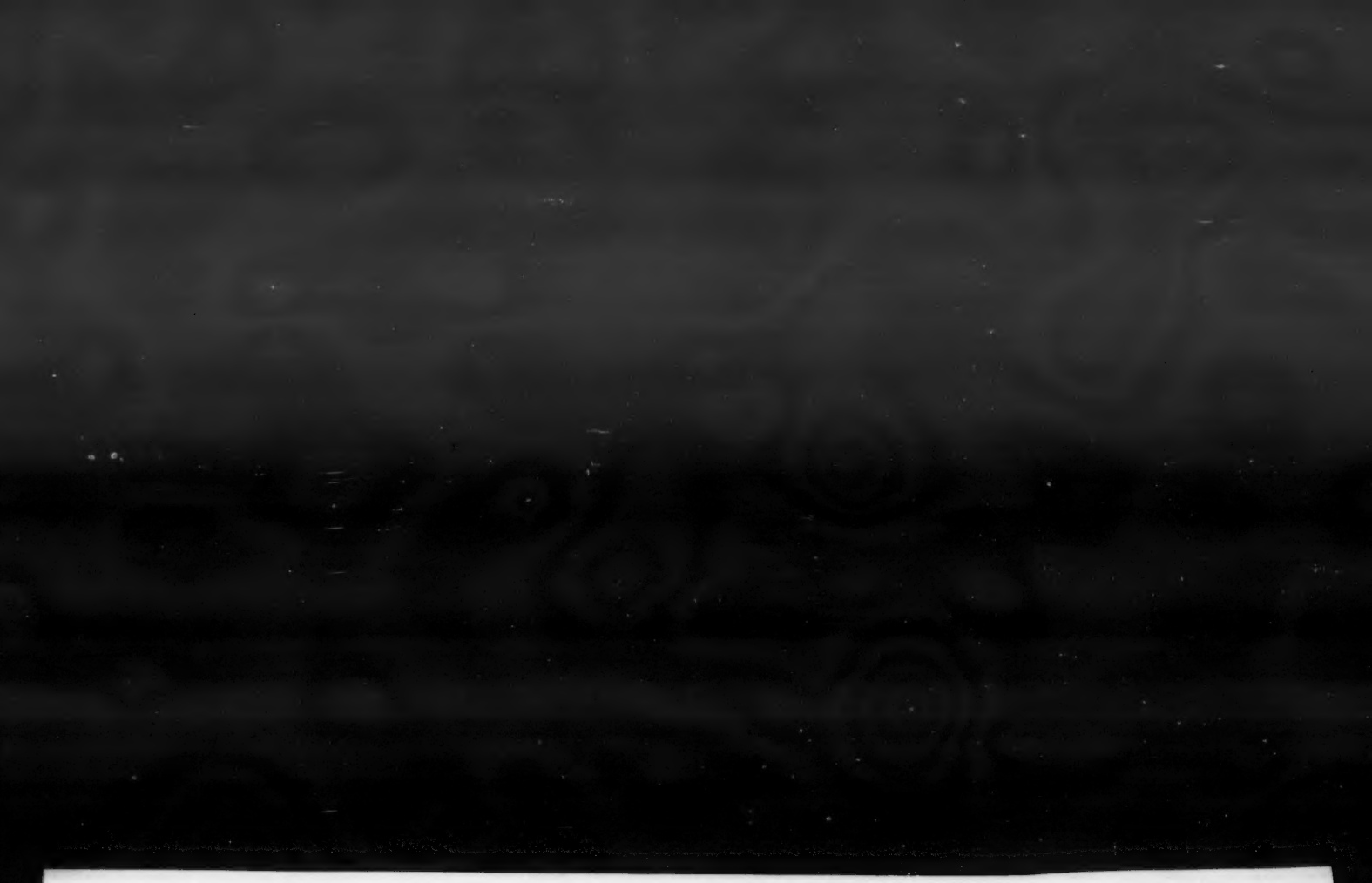
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